

# PALEOCENE BIVALVES FROM THE PEBBLE POINT FORMATION, VICTORIA, AUSTRALIA

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Thirty-two bivalve taxa are recorded from the Paleocene Pebble Point Formation, Otway Basin, Victoria, Australia, of which 11 are newly described and 17 are recorded in open nomenclature. New species are *Lamellinucula pyrenoides*, *Australoneilo cultrata*, *Limopsis rupestris*, *Myrtea faseolata*, *Cyamlocardium silicula*, *Astarte (Astarte) notalis*, *Venericardia (Rotundicardia) petraea*, *Carditellopsis bellissima*, *Bertinella lapidaria*, *Dosinia (Dosinobia) saxatilis*, *Callistina (Tikia)? scopulensis*. The environment was one of high energy, shallow water and the climate was probably cool temperate. The fauna is composed mostly of genera that were cosmopolitan during the Paleocene and shows no close affinity with any other, suggesting considerable isolation from other Paleocene faunas. *Lahillia* and *Australoneilo* are the only taxa with a particular Antarctic and South American affinity and *Lahillia*, *Dosinia (Dosinobia)* and *Callistina (Tikia)?* have an affinity with New Zealand. *Eotrigonia* is the only endemic genus present.

**Keywords:** Bivalvia, Late Paleocene, Otway Basin, Victoria, Australia, palaeoecology, biogeography, taxonomy, new taxa.

PALEOCENE MOLLUSCAN FAUNAS occur in Australia in the Carnarvon, Perth and Otway Basins, but despite their importance have received little attention. Factors in this neglect are the restricted and poor outcrop, the sparsely fossiliferous nature of the rocks and the very hard matrix making extraction difficult.

Paleocene faunas are potentially important in providing clues to the origin of the later Tertiary faunas of Australia and to the nature of the fauna present in the region at the time of the separation of the Australian plate from the Antarctic plate. They are also critical for understanding the faunal recovery and evolutionary radiation following the end-Cretaceous mass extinction.

The bivalves described here occur in the Pebble Point Formation in the Otway Basin, Western Victoria. Of the other Paleocene formations of Australia, the Cardabia Calcarene (including the Boongarooda Greensand Member, Wadera and Pirie Members) in the Carnarvon Basin, Western Australia contains few bivalves and there is nothing in common with the Pebble Point Formation; the King's Park Shale in the Perth Basin is known only from subsurface (McGowran 1964).

Molluscs now known to be of Paleocene age were first collected by C. S. Wilkinson from Pebble Point (his locality Aw 6) during his geological survey of the Otway Ranges and coast in 1864 (Wilkinson 1865). The molluscs were never described, though McCoy (1876) recorded *Cucullaea*

*corioensis* 'very thick variety' from east of the Gellibrand River based on Wilkinson's collection.

## PREVIOUS WORK

The only formally named molluscs in the fauna of the Pebble Point Formation are two nautiloid cephalopods, *Aturoidea distans* and *Nautilus victorianus* (Teichert 1943); three bivalves, *Nuculana paucigradata*, *Cucullaea (Cucullona) psephea* and *Lahillia australica*, and a scaphopod, *Dentalium (Fissidentalium) gracilicostatum* (Singleton 1943), all described from collections made by George Baker, who studied the stratigraphy and sediments of the coastline between Moonlight Head and Curdies Inlet (Baker 1943). Teichert (1943) and Singleton (1943) recognised that the fauna was the oldest known from the Australian Tertiary. Teichert concluded that the age was Eocene and Singleton that the age was Early Eocene or possibly Paleocene. Singleton recognised links between the bivalves and those in South America, Antarctica and New Zealand.

In 1986 Darragh described a further bivalve, *Eotrigonia paleocenica*.

The foraminiferal fauna was described by McGowran (1965), who concluded that it was of middle Paleocene age, correlated with Zone P3, *Globorotalia pusilla*-*Globorotalia angulata* zone. Later McGowran (1991) refined this cor-

relation, stating that the Pebble Point marine transgression fell near the P4/P5 boundary, late Paleocene (Thanctian or Seelandian).

## LOCALITY AND NATURE OF FORMATION

The Pebble Point Formation outcrops in coastal cliffs between Moonlight Head and the mouth of the Gellibrand River. It transgressively overlaps the early Cretaceous Otway Group sediments and is conformably overlain by the Dilwyn Formation (Late Paleocene–Early Eocene) (Baker 1950). Molluscs are extremely rare in the formation. Inland it outcrops in western Victoria in the valleys of the Wannon River and Grange Burn west of Hamilton and at Killara Bluff on the Glenelg River and opposite at Bahgallah south of Casterton. These inland outcrops are highly ferruginised and weathered. No carbonate has survived and fossils are difficult to determine. At Killara Bluff where the calcium carbonate of the fossils has been replaced by limonite (Kenley 1951, 1971), Kenley (1954) recorded 16 m of ferruginous sands and fine conglomerates containing *Nuculana paucigradata*, *Cucullaea* (*Cucullona*) *psephaea*, *Eotrigonia* sp., *Lalillia australica*, *Panopea* sp. and *Aturoidea distans*.

Spencer-Jones (1971) recorded thick-bedded, heavily ferruginised coarse to fine gravels, coarse and fine sandstone, pebbly sandstone and limonitic siltstone in the valleys of the Wannon River and Grange Burn in the area of the Parkhill and Morgiana Estates and extending southwest to the Miakite Creek valley. A maximum thickness of 61 metres was recorded near the Parkhill Estate southwest of Wannon. These sediments overlap the Late Cretaceous Otway Group sediments and in turn are overlain by formations of the Oligocene to Miocene Heytesbury Group.

Fossils, abundant at some localities, are found in these sediments as moulds, but in most cases so ferruginised that determination is not possible. At some localities where the ferruginous siltstones outcrop, well preserved moulds can be found which enable a determination to be made. Fossils collected by D. Spencer-Jones in 1964 from two such localities have been examined. The bivalve fauna is reasonably diverse and all determinable fossils occur in the Pebble Point Formation on the coast. Therefore, it is reasonable to infer that these ferruginous sediments are a lateral extension of the Pebble Point Formation. This means that the Paleocene marine incursion in the Otway Basin was far more extensive than previously realised and extends inland nearly as far as the later Miocene incursion.

On the Otway coast the formation consists of 20–30 m of coarse quartzose sandstone, grits, conglomerate and gritty ferruginous clays (Baker 1950). When fresh the rock matrix has a bluish colour. In outcrop along the coast it is highly ferruginous and cemented owing to oxidation, but the carbonate fossils are still preserved. Fossils are not uniformly distributed but found in a narrow band about 3 m thick about 10 m above the base of the formation. Other macrofossils present are rare solitary corals, shark teeth, fish vertebrae and crab remains.

Matrix adhering to the fossils is very fine-grained, limonitic, often cemented, with fine to coarse quartz grains embedded in it. In less weathered matrix glauconite pellets are common. The ferruginous matrix contains siderite which in many cases bonds chemically to the shell smothering fine detail of the shell surface. It is impossible to remove this coating without damage to the shell itself.

Since it is very difficult to collect fossils *in situ*, recourse has to be made to beach boulders, from which most fossils have been collected. Fossils in partially weathered boulders can be separated from the matrix by careful picking with needles. Fossils exposed on the surface of indurated boulders can only be collected with hammer and chisel and their preparation is extremely difficult and time-consuming.

## Locality

The details of the localities from which material was collected are as follows. The numbers are from the Museum of Victoria fossil locality register and are used throughout to save repetition.

PL 3001 SE side of Dilwyn Cove, N side of Bell Point, 6 km SE of Princetown, from boulders on beach derived from 0.5 m grey (weathered) sandstone about 15 m above beach, Victoria, Princetown 903100.

PL 3002 N side of Dilwyn Cove, S side of Pebble Point, G.S.V. loc. Aw6, 5 km SE of Princetown, Victoria, Princetown 900103.

PL 3003 Cove between Buckley Point and Point Pember, 4.5 km SE of Princetown, Victoria, Princetown 894109.

PL 3004 Shelly band about 10 m above beach, NW side of Buckley Point, 4 km SE of Princetown, Victoria, Princetown 894109.

PL 3005 W end of large slip at Killara Bluff at top section, allot. 4, sect. A, Parish of Killara, Victoria, Dartmoor WD313291.

PL 3006 Ironstone about 100 m above river, right



bank of Glencg River on Hazell Bank, Bahgallah, Victoria, Dartmoor WD324296.

PL3176 Cutting on Morgiana Road, about 5 km south of Wannan, left bank Grange Burn, Coleraine WD 760267.

PL3177 South flowing gully running into right bank of Grange Burn, about 0.5 km south of Clayton's Road, 3.5 km southeast of Wannan, Coleraine WD729253.

Most of the material described here was collected from fallen boulders at PL3003.

## ENVIRONMENT AND DEPOSITION

Baker (1950) suggested that the Pebble Point Formation consisted of littoral, shallow-water deposits and McGowran (1965) stated that the foraminifera indicated a shallow-water, open marine environment. The bivalves suggest a similar environment. A majority of specimens show signs of abrasion suggesting that the specimens were transported some distance before burial. There are few articulated pairs of valves extant. Of these pairs, specimens of *Bertinella? lapidaria* sp. nov. are the most common. Even the infaunal species, such as *Panopaea* sp., have the valves disarticulated suggesting exhumation after death. Many species have heavy robust shells. Such evidence, together with the coarse particles in the host rock, suggest a high energy, shallow-water environment.

## BIVALVE FAUNA

There are 32 taxa recorded here but three are represented by such poor material that comparison with other taxa is not possible. In addition there are two other taxa whose relationships are not clear as the material available may consist of juveniles. The fauna so far identified is as follows:

Nuculidae	<i>Lamellinucla pyrenoides</i> sp. nov.
Nuculanidae	<i>Comitileda</i> sp.
	<i>Ledina paucigradata</i> Singleton
	<i>Neilo (Australoneilo) cultrata</i> sp. nov.
Cucullaeidae	<i>Cucullaea psephea</i> Singleton
Limopsidae	<i>Limopsis rupestris</i> sp. nov.
Pinnidae	<i>Pinna</i> sp.
Pteriidae	<i>Electroma</i> sp.
Propeamussiidae	<i>Parvamussium</i> sp.
Anomiidae	<i>Anomia</i> sp.
Limidae	limid
Gryphacidae	<i>Pycnodonte (Plygraea)</i> sp.
Trigoniidae	<i>Eotrigonia paleocenica</i> Darragh

Lucinidae	<i>Jagolucina?</i> sp.
	lucinid A
	lucinid B
	<i>Myrtca faseolata</i> sp. nov.
Thyasiridae	<i>Thyasira</i> sp.
Ungulinidae	<i>Fclaniella (Zemysia)</i> sp.
Erycinidae	<i>Borniola</i> sp.
Cyamiidae	<i>Cyamiocardium silicula</i> sp. nov.
Astartidae	<i>Astarte (A.) notialis</i> sp. nov.
Carditidae	<i>Venericardia (Rotundicardia) petraea</i> sp. nov.
	<i>Carditelopsis bellissima</i> sp. nov.
Lahilliidae	<i>Lahillia australica</i> Singleton
Tellinidae	<i>Bertinella lapidaria</i> sp. nov.
Veneridae	<i>Dosinia (Dosinobia) saxatilis</i> sp. nov.
	<i>Callistina (Tikia)? scopulensis</i> sp. nov.
Corbulidae	<i>Caryocorbula</i> sp.
Hiatellidae	<i>Panopca</i> sp.
Cuspidariidae	<i>Cuspidaria</i> sp.
Verticordiidae	<i>Verticordia</i> sp.

Table showing numbers of specimens used in this study.

<i>Limopsis rupestris</i> sp. nov.	394
<i>Astarte (A.) notialis</i> sp. nov.	319
<i>Ledina paucigradata</i> Singleton	288
<i>Bertinella lapidaria</i> sp. nov.	114
<i>Cucullaea psephea</i> Singleton	94
<i>Venericardia (Rotundicardia) petraea</i> sp. nov.	82
<i>Anomia</i> sp.	81
<i>Dosinia (Dosinobia) saxatilis</i> sp. nov.	65
<i>Cyamiocardium silicula</i> sp. nov.	64
<i>Carditelopsis bellissima</i> sp. nov.	51
<i>Lahillia australica</i> Singleton	42
<i>Eotrigonia paleocenica</i> Darragh	31
<i>Lamellinucla pyrenoides</i> sp. nov.	28
<i>Neilo (Australoneilo) cultrata</i> sp. nov.	24
<i>Callistina (Tikia)? scopulensis</i> sp. nov.	15
<i>Myrtca faseolata</i> sp. nov.	13
<i>Comitileda</i> sp.	11
<i>Jagolucina?</i> sp.	10
<i>Electroma</i> sp.	7
<i>Parvamussium</i> sp.	7
<i>Caryocorbula</i> sp.	6
<i>Pycnodonte (Plygraea)</i> sp.	6
<i>Verticordia</i> sp.	4
<i>Cuspidaria</i> sp.	4
lucinid B	4
<i>Pinna</i> sp.	4
<i>Panopca</i> sp.	4
limid	3
<i>Thyasira</i> sp.	2
<i>Fclaniella (Zemysia)</i> sp.	2
<i>Borniola</i> sp.	1
lucinid A	1
Total	1718

### TROPHIC COMPOSITION

A valid trophic analysis of the fauna is not possible, because of the problems associated with collecting an unbiased sample. However, notwithstanding these problems, some broad generalisations can be made. It will be seen by comparing the numbers of individuals given above with the generalised groupings below, that the fauna as a whole is dominated by infaunal, suspension feeding bivalves with a significant infaunal, deposit feeding component. Three infaunal species comprise well over half (62%) the number of specimens. This pattern of composition suggests very shallow water. Nuculanids, tellins and astartids are very common elements in Recent northern hemisphere, cool shallow-waters (Thorson 1957), but *Limopsis* does not seem to have been recorded as a common element in association with them. Attempts to compare a Paleocene assemblage from the southern hemisphere with Recent faunas of the northern hemisphere, or any other Recent fauna, should be treated with caution, because of the great difference in time and space. Also two of the most common elements in the Pebble Point fauna, *Limopsis* and *Astarte*, have living representatives which are eurybathyal. *Limopsis aurita* occurs from 38 to 3175 m and *Astarte sulcata* from 10 to 2000 m (Ekman 1967).

#### Generalised grouping of species according to feeding type and habitat

##### Infaunal deposit feeding:

*Lamellinucula pyrenoides* sp. nov., *Comitileda* sp., *Ledina paucigradata* Singleton, *Neilo (Australoneilo) cultrata* sp. nov., *Bertinella lapidaria* sp. nov., *Verticordia* sp.

##### Infaunal suspension feeding:

*Cucullaea psepheia* Singleton, *Limopsis rupestris* sp. nov., *Eotrigonia paleocenica* Darragh, *Jagolucina?* sp., lucinid A, lucinid B, *Myrtea faseolata* sp. nov., *Thyasira* sp., *Felaniella (Zentysia)* sp., *Borniola* sp., *Cyamiocardium silicula* sp. nov., *Astarte (A.) notialis* sp. nov., *Venericardia (Rotundicardia) petraea* sp. nov., *Carditellopsis bellissima* sp. nov., *Lahillia australica* Singleton, *Dosinia (Dosinobia) saxatilis* sp. nov., *Callistina (Tikia)? scopulensis* sp. nov., *Caryocorbula* sp., *Panopea* sp.

##### Semi-infaunal byssate, suspension feeding:

*Pinna*

##### Epifaunal, byssate, suspension feeding:

*Electroma* sp., *Parvamussium* sp., *Anomia* sp., limid.

##### Epifaunal, attached, suspension feeding:

*Pycnodonte (Phygraea)* sp.

##### Infaunal carnivore:

*Cuspidaria* sp.

### PREDATION

Countersunk boreholes (total 57) are present on 54 of the 1781 specimens studied. The holes were probably bored by a small species of naticid gastropod present in the fauna. Most of the holes (82%) were bored into 44 specimens of *Astarte (A.) notialis* sp. nov. One specimen had two uncompleted holes, a second had one uncompleted and one completed hole and a third specimen had two completed holes. All other bored *Astarte* had only one borehole. Other completed holes were found on specimens of *Jagolucina?* (3), *Cyamiocardium silicula* sp. nov. (3), *Carditellopsis bellissima* sp. nov. (3), and *Bertinella lapidaria* sp. nov. (2).

### TEMPERATURE

It is only possible to give a very general indication of the water temperature in which the fauna lived. The fauna as a whole is similar to northern hemisphere Boreal faunas (see below) which presumably lived in cool temperate water. There are no genera present which are found in the warm-water faunas of the Paleocene of Africa and Asia. Species of genera such as *Myrtea*, *Thyasira*, *Felaniella*, *Borniola*, and *Carditellopsis* are found living in cold to warm temperate waters off eastern Australia.

### RELATIONSHIPS WITH OLDER AUSTRALIAN FAUNAS

The only Late Cretaceous fauna described from Australia is that from the Miria Formation, Carnarvon Basin, Western Australia (Darragh & Kendrick 1991). Given the geographical and stratigraphical separation of this fauna from that at Pebble Point, it could not be expected that they would have much in common and, indeed, only three genera in the Miria fauna might have provided an ancestor for Pebble Point genera: *Pycnodonte (Phygraea)*, *Panopea* and *Trigonia*. The first two are cosmopolitan genera and the Pebble Point representatives may easily have been derived from some other source, the Antarctic or New Zealand for instance. However, *Trigonia miriana* has many features similar to the Pebble Point *Eotrigonia paleocenica* and may belong to an ancestral group of the Pebble Point taxon (Darragh 1986).



### RELATIONSHIPS WITH YOUNGER FAUNAS

Species of *Comitileda*, *Cucullaea*, *Linuopsis*, *Pinna*, *Parvanussium*, *Anomia*, *Pynchodonte*, *Eotrigonia*, *Rotundicardia*, *Carditellopsis*, *Panopea*, *Cuspidaria* and *Verticordia* are found in Eocene rocks in the Otway Basin. Though most of the Eocene species do not seem to be closely related to the Paleocene species, the species of *Linuopsis*, *Rotundicardia* and *Carditellopsis* do seem to be related. The species of *Comitileda*, however, does seem to be close to Oligocene and Miocene species and possibly represents the beginning of a lineage. Other than the Paleocene record, *Myrtea* is found from Pliocene to Recent, *Thyasira* is known from Middle Miocene to Recent and *Zemysia*, *Cyamio-cardium* and *Borniola* are only known in the Recent fauna of Australia. It seems unlikely that the Paleocene species are directly related to the Miocene and living species, but species of the latter two genera are small to minute and too much emphasis should not be placed on their absence because such molluscs from the Australian Tertiary have been little studied.

Pebble Point genera not found above the Paleocene in Australia are *Lamellinucula*, *Ledina*, *Australoneilo*, *Astarte*, *Lahillia*, *Bertinella*, *Dosinobia* and *Caryocorbula*.

### BIOGEOGRAPHY

An authoritative biogeographic analysis of the Pebble Point fauna is not yet possible because the generic placement of several of the species is doubtful. Equally the generic placement of many species described from other Paleocene faunas around the world is in doubt. Despite these problems some general conclusions can be made, however, as the taxonomy and relationships of Paleocene species become better known, modification will no doubt be required. It should also be emphasised that these conclusions are drawn from a study of the bivalves only and information from the gastropods may modify them.

Paleocene faunas are not particularly widespread throughout the world and some have not yet been the subject of modern revision, making comparison difficult. They fall into four very broad groupings.

1. An Early Paleocene Boreal fauna found in Europe extending from Denmark in the west as far east as the Volga Basin in Ukraine and possibly to Tashkent (Ravn 1939; Makarenko 1970; Anderson 1973, 1974). In the Late Paleocene, this fauna extended further south into the Anglo-Franco-Belgian Basin.

2. A temperate to warm-temperate fauna in the Early Paleocene found in Europe in Belgium and France (Glibert & Van der Poel 1973) and in America from New Jersey in the north as far south as Brazil (Gardner 1933). The Paleocene fauna of the United States Pacific coast could also be considered as part of this group (Zinsmeister 1983).

3. A tropical to warm water, Early to Late Paleocene Tethyan fauna extending from central west Africa and north Africa eastwards as far as India and Burma (Adegoke 1977).

4. A southern hemisphere group of faunas from isolated localities of varying ages in New Zealand (Finlay & Marwick 1937), Australia, Antarctica (Zinsmeister & Macellari 1988) and southern South America.

The first and third of the above groups are relatively homogeneous. The second group can be divided into an American subgroup of relatively homogeneous faunas and a European subgroup. The two subgroups have much in common (Gardner 1933).

The Pebble Point fauna has 10 genera, or about one third of the genera present, in common with group one. These genera are all regarded as cosmopolitan in cool to temperate waters. Many cosmopolitan or widely distributed genera are also shared with the second group. None of the Pebble Point genera, except the cosmopolitan genus *Pynchodonte* (*Phygraea*), are shared with group three.

The only Paleocene faunas in the southern hemisphere are those at Pebble Point, the Wangaloan fauna of New Zealand; on the Antarctic Peninsula and in southern South America.

The Wangaloan fauna, a moderately diverse, shallow water fauna comprising about 20 genera is significantly older than that at Pebble Point, being early Teurian or Danian (Beu & Maxwell 1990). Faunas on the Antarctic Peninsula are also diverse and are of shallow water origin, but are either significantly older, Late Cretaceous ranging into the Early Paleocene, or much younger, Mid to Late Eocene (Zinsmeister & Macellari 1988; Stillewell & Zinsmeister 1992). Paleocene faunas in southern South America are so poorly known that a comparison has not been attempted.

At Pebble Point there are 32 bivalve taxa, of which only six seem to be related to taxa from the Wangaloan (*Ledina*, *Cucullaea*, *Electrona*, *Myrtea*, *Lahillia* and *Dosinobia*). The Pebble Point species of *Ledina*, *Cucullaea*, *Lahillia* and *Dosinobia* are close enough to the Wangaloan taxa to suggest that they are descended from them. A further three taxa (*Comitileda*, *Zemysia*, *Caryo-*

*corbula*) seem related to taxa from the Eocene of New Zealand.

Only five taxa seem to be related to Antarctic forms; *Australoneilo*, *Cucullaea*, *Pinna*, *Lahillia* and *Panopea*. These taxa are related to both Late Cretaceous and Late Eocene Antarctic forms. Of these *Cucullaea* and *Lahillia* are shared with New Zealand. *Electroma* also occurs in the Late Eocene of Antarctica. However, *Cucullaea*, *Pinna* and *Panopea* are cosmopolitan genera and cannot be regarded as necessarily indicating a close relationship between faunas.

Both *Astarte* and *Cyaniocardium* occur in Antarctic living faunas. Except as recorded here, *Astarte* is not known living or fossil either in Australia or New Zealand. *Astarte* is considered a typical member of cool-water boreal faunas.

In general the Pebble Point bivalves suggest considerable isolation from other Paleogene faunas and lend little support to the idea that southern Australia, or at least the Otway Basin, was part of the late Cretaceous-early Tertiary Weddellian Province (Zinsmeister 1979). The only unequivocal Weddellian taxa present are *Lahillia* and *Neilo* (*Australoneilo*) which presumably had a circum-polar distribution. Other characteristic Weddellian taxa such as aporrhoids and struthiolariids are not present.

This comparative isolation of the Pebble Point fauna can be explained by the disposition of the Australian continent *vis-à-vis* Antarctica. Accepting the scenario as depicted by Frakes et al. (1987, Figs 8-13) and Veevers et al. (1991, Figs 6-8), it would seem that a narrow east-west seaway open to the west, but restricted or blocked in the east by the South Tasman Rise, existed between Australia and Antarctica from Cenomanian times through into the Paleocene. Circulation of water and hence migration or transport of larvae from the east would have been limited, thus preventing easy migration of taxa from the New Zealand region and the Antarctic Peninsula area. Most of the taxa present were representatives of cosmopolitan groups, whose larvae would have been pelagic and long-lived, allowing wide dispersal.

The fauna of the Maastrichtian Miria Formation is also dominated by cosmopolitan generic taxa (Darragh & Kendrick 1991; Darragh & Kendrick 1994) suggesting isolation of the Australian plate at that time. Apart from *Eotrigonia*, endemic Australian bivalve taxa had not evolved by Paleocene time and it was not until the Late Eocene that endemic elements developed. By this time the fauna had also received an influx of new immigrants from the Tethyan and New Zealand regions and the basic

elements of the modern molluscan fauna were established (Darragh 1985).

## TERMINOLOGY

The tooth notation used in the descriptions is that of Boyd & Newell (1969).

All specimens are housed in the Invertebrate Palaeontology Collection, Natural History Division, Museum of Victoria, register prefix NMV P.

Figured specimens were all whitened before being photographed.

## SYSTEMATICS

### Family NUCULIDAE

#### *Lamellinucula* Schenck, 1944

*Type species.* *Nucula tamatavica* Odhner, 1943, Recent, Madagascar.

#### *Lamellinucula pyrenoides* sp. nov.

Fig. 1J, N, Q, T

*Description.* Shell of small size (4-5 mm), ovate, strongly inequilateral, equivalve, moderately inflated, opisthogyrate, umbo situated about  $\frac{1}{4}$  to  $\frac{1}{5}$  from posterior end, valves slightly flattened to depressed on posterior flank. Lunule very narrow, barely developed. Escutcheon very narrow. Sculpture of 21 to 39 fine, sharp, commarginal ribs, slightly narrower than interspaces and on some specimens with a thin anastomosing riblet between some ribs. End of ribs at anterior margin against escutcheon somewhat thicker. Inter-rib spaces with fine, close spaced, radial costae. Sculpture begins about 1 mm from umbo; anterior to this valve is smooth. Muscle scars subcircular. Hinge with 7 posterior and 13 anterior teeth. Resilifer directed forwards, not projecting. Internal valve margin with fine denticulations.

#### *Dimensions*

Holotype P142956	L 5.1	H 4.1	T 3.0 (pr)
Paratype P142957	4.2	3.5	

*Type material.* Holotype P142956, collected T. A. Darragh, 17 February 1981; Paratype P142957, collected T. A. Darragh, 24 November 1992.

*Type locality.* PL3003.

*Occurrence and material.* PL3003 (27 specimens), PL3004 (1 specimen).

*Remarks.* There is nothing quite like this taxon in the Australian Eocene, though species which may possibly belong in the genus occur in the Oligocene



and Miocene. The genus has a cosmopolitan distribution and is known from the Paleocene of Europe, Asia and North America. There is nothing like it recorded from the early Tertiary of New Zealand or the Antarctic.

There is possibly another species of nuculid present represented by one specimen with a smooth valve surface and denticulate internal ventral margin. It is triangular in shape rather than oval. Also present are 16 very small (0.8–1 mm) specimens that are thick shelled, tumid and triangular with a smooth external valve surface and smooth internal ventral margin. It is not clear if these specimens are juveniles of the smooth species or represent yet another species of nuculid, possibly an *Austronucula*.

#### Family NUCULANIDAE

##### *Comitileda* Iredale, 1924

*Type species.* *Leda miliacea* Hedley, 1902, Recent, New South Wales.

Until a proper revision of the small rostrate nuculanids is undertaken, I follow Maxwell (1992) in using this genus rather than *Ledina* to which Australian species have been previously assigned. The genus occurs in New Zealand from Middle Eocene to Recent and in Australia from Paleocene to Recent.

##### *Comitileda* sp. cf. *C. brachyryncha* Maxwell, 1992

###### Fig. 1K–M

*Description.* Shell small (2–3 mm), ovate, almost equilateral, somewhat tumid, slightly rostrate at posterior end. Umbo central, projecting slightly, very slightly opisthogyral. Anterior dorsal margin gently convex; anterior margin strongly convex, merging into convex ventral margin; ventral margin gently convex, concave where it merges with the posterior margin; posterior dorsal margin straight; posterior margin short, strongly convex. Surface of valve smooth except for growth ridges. Hinge with 10 posterior and 8 anterior chevron-shaped teeth, apex directed towards umbo. Muscle scars subequal, barely visible; pallial line with shallow rounded sinus. Internal valve margin smooth.

###### *Dimensions*

Figured specimen P142863	L 2.7	H 1.9
Figured specimen P143862	2.2	1.4

*Figured material.* Figured specimen P142863, collected T. A. Darragh, 8 March 1977; Figured specimen P142862, collected T. A. Darragh, 22 November 1993.

*Occurrence and material.* PL3003 (11 specimens).

*Remarks.* One specimen is a pair with a counter-sunk gastropod drill hole in the right valve.

This species bears a very close resemblance to *Comitileda brachyryncha* Maxwell, Eocene, New Zealand and also to *C. praelonga* Tate, Oligocene to Miocene, Australia. The latter is more rostrate, slenderer and more pointed at the posterior end, but the differences are slight. It is more tumid than *C. miliacea* but is not as elongate and the umbo is not so opisthogyral. *Leda rhamphidia* Cossmann, Paleocene, Belgium is somewhat similar in shape to *C. miliacea*.

##### *Ledina* Dall, 1898

*Type species.* *Leda smirna* Dall, 1898 (= *Leda eborea* Conrad, 1860 non Conrad, 1846), Eocene, United States of America.

##### *Ledina paucigradata* (Singleton, 1943)

###### Fig. 1H–I, O–P, R–S, U–V

*Nuculana paucigradata* Singleton, 1943: 268, pl. 12, fig. 1a, b.

*Description.* Shell solid of medium to large size for genus (10–14 mm), elongate-ovate, posteriorly rostrate, equivalve, moderately inflated, umbones low, situated at about  $\frac{1}{3}$  distance from anterior border. Anterior dorsal margin straight, merging into the strongly convex anterior margin; ventral margin regularly and gently curved, abruptly merging into posterior margin; posterior margin short, in some specimens rounded to blunt point; posterior ventral margin slightly convex, abruptly truncated by posterior margin.

Surface of valves sculptured with fine growth striae only.

Hinge with 10–14 anterior teeth, chevron shaped, pointed toward umbo, becoming weaker toward umbo; 19–23 posterior chevron shaped teeth, becoming straighter and vertically aligned toward umbo. Small triangular resilifer between anterior and posterior tooth series.

Anterior muscle scar laterally elongated; posterior scar vertically elongate. Pallial sinus shallow, wide, usually not visible. Internal margins of valves smooth.

###### *Dimensions*

Holotype P127990	L 11	H 6	T 2
Figured specimen P142961	14	7	2.3 LV
Figured specimen P142962	12	7	2.3 RV
Figured specimen P142960	11	6	4.5 Pair
Figured specimen P142963	12	6	6.6 Pair

*Types.* Holotype P127990 (MUGD 1868), left valve, collected G. Baker, January 1942. The holotype has

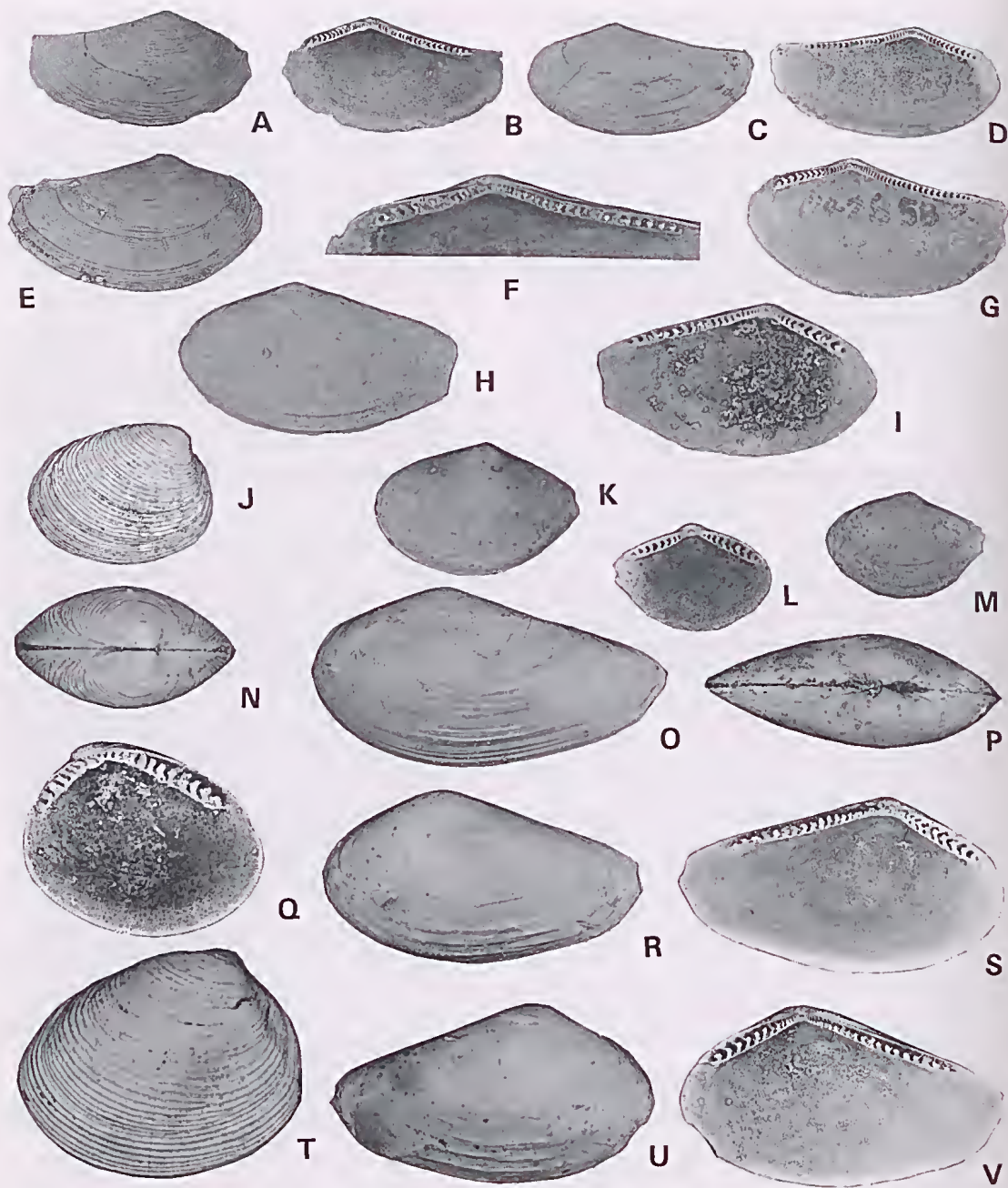


Fig. 1. A-G, *Neilo (Australoneilo) cultrata* sp. nov. A-B, NMV P142861, paratype, PL3003,  $\times 1.8$ . C-D, NMV P142859, paratype, PL3003,  $\times 1.8$ . E, G, NMV P142858, holotype, PL3003,  $\times 1.5$ . F, NMV P142860, paratype, PL3003,  $\times 3.5$ . H-I, O-P, R-S, U-V, *Ledina paucigradata* (Singleton). H-I, NMV P127990, holotype, second point NW of Pebble Point,  $\times 3.5$ . O, NMV P142961, PL3003,  $\times 3.5$ . P, NMV P142960, PL3003,  $\times 3.7$ . R-S, U-V, NMV P142963, pair, PL3003,  $\times 3.75$ . J, N, Q, T, *Lamellinucula pyrenoides* sp. nov. J, NMV P142957, paratype, PL3003,  $\times 6.2$ . Q, NMV P142957,  $\times 8.1$ . N, NMV P142956, holotype, PL3003,  $\times 6.1$ . T, NMV P142956, holotype,  $\times 9.6$ . K-M, *Comitileda* cf. *C. brachyryncha* Maxwell. K, NMV P142862, PL3003, 13. L-M, P142863, PL3003,  $\times 8.1$ .



approximately one millimetre broken off the posterior end. Figured specimens, P142960, P142961, P142962, collected T. A. Darragh, 8 March 1977; Figured specimen P142963, collected T. A. Darragh, 27 November 1972.

*Type locality.* Coastal cliffs 2½ miles south-east of Princetown, Victoria, second point north-west of Pebble Point (= PL 3004).

*Occurrence and material.* PL3001 (14 specimens), PL3003 (240 specimens), PL3004 (34 specimens).

*Remarks.* This is one of the most common molluscs in the fauna. Paired valves are very uncommon. *L. paucigradata* is very similar in overall features to the New Zealand Paleocene *L. taioma* (Finlay & Marwick 1937), but is more elongate, the umbo is not so centrally situated and the anterior dorsal margin is straight rather than concave as in *L. taioma*.

Compared with the type species of the genus, *L. smirna* Dall (Gardner 1933), *paucigradata* is more elongate and not so equilateral. Both *L. fresnoensis* (Diekerson) and *L. duttonae* (Vokes) (Paleocene and Eocene of California) have better developed lunules and esuteheons (Moore 1983).

Darragh (1985) recorded *L. paucigradata* from the Rivernook Member of the Dilwyn Formation. Collection of better preserved material shows that the determination was in error.

Apart from the occurrence here, the genus is known only from the Paleocene to Eocene of New Zealand and North America.

### *Neilo* (Australoneilo) Zinsmeister 1984

*Type species.* *Australoneilo rossi* Zinsmeister, 1984, Late Eocene, Antarctica.

Zinsmeister (1984) distinguished *Australoneilo* from *Neilo* by the absence of commarginal ribbing and by it having a poorly developed rostrum. These differences are slight, particularly as some species of *Neilo* have obsolescent ribbing, so subgeneric status seems appropriate. *Australoneilo* may be distinguished by its more prominently curved rather than almost straight ventral margin and by the lack of a prominent umbo to posterior ventral margin ridge. *Neilo* also has a prominently rectangular truncated posterior margin.

### *Neilo* (Australoneilo) *cultrata* sp. nov.

Fig. 1A-G

*Description.* Shell of small size for subgenus (18–21 mm), narrow, elongate, subquadrangular, moderately swollen medially and tapering gently

posteriorly. Umbo small, slightly projecting, orthogyr, situated about ⅓ valve length from anterior end. Anterior margin somewhat sharply rounded; anterior dorsal margin concave; posterior dorsal margin concave, abruptly truncated by posterior margin; ventral margin long, gently convex. Posterior umbonal ridge ill defined.

Lunule very narrow and weak. Esetecheon narrow, extending to posterior margin, sharply defined by ridge. One or two shorter ridges within esutecheon.

Sculpture consisting of 8 to 14 widely spaced, somewhat irregular, thin, commarginal riblets extending to about 2.5–3 mm from beak, present on central flank but not present on posterior or anterior flanks. Remainder of valve sculptured with growth increments only.

Hinge with chevron shaped teeth with apices directed toward umbo, becoming thinner and straightening toward beak and meeting under it. 15 to 19 anterior teeth and 22 to 29 posterior teeth. No resilifer.

Pallial sinus wide, moderately deep, extending about halfway between umbo and posterior border, sloping gently ventrally. Muscle scars barely visible, small, oval; anterior elongated dorso-ventrally; posterior elongated laterally. Internal valve margin smooth.

#### *Dimensions*

Holotype P142858	L 21	H 11	T 3.5
Paratype P142859	18	9	3
Paratype P142861	17	9	3.5

*Type material.* Holotype P142858, left valve; Paratype P142859, right valve, collected T. A. Darragh, 27 November 1977; Paratype P142861, right valve, collected T. A. Darragh, 13 November 1984.

*Type locality.* PL3003.

*Occurrence and material.* PL 3001 (6 specimens); PL 3003 (14 specimens); PL3176 (3 specimens); PL3177 (1 specimen). 2125–2131 feet, Kaladbro 2 bore (1 specimen); Mersey Valley Oil Co., 1926; Mumbannar no. 1, 1492–1502 feet, 37°5'37"S, 141°03'19"E, 4 km NE of Mumbannar (2 specimens).

*Remarks.* In outline this species is very close to the type species, *N. (A.) rossi*, but is about half the size, slightly narrower and more elongate and has riblets on the umbo. *N. (A.) gracilis* (Wilekens 1907), Late Cretaceous–Paleocene, Southern Patagonia and Seymour Island and *N. (A.) casei* Zinsmeister & Macellari 1988, Paleocene, Seymour Island both lack the fine umbonal ribs of *N. (A.) cultrata* and are not so elongate.

The subgenus was previously known only from the Late Cretaceous, Paleocene and Eocene of Antarctica and South America.

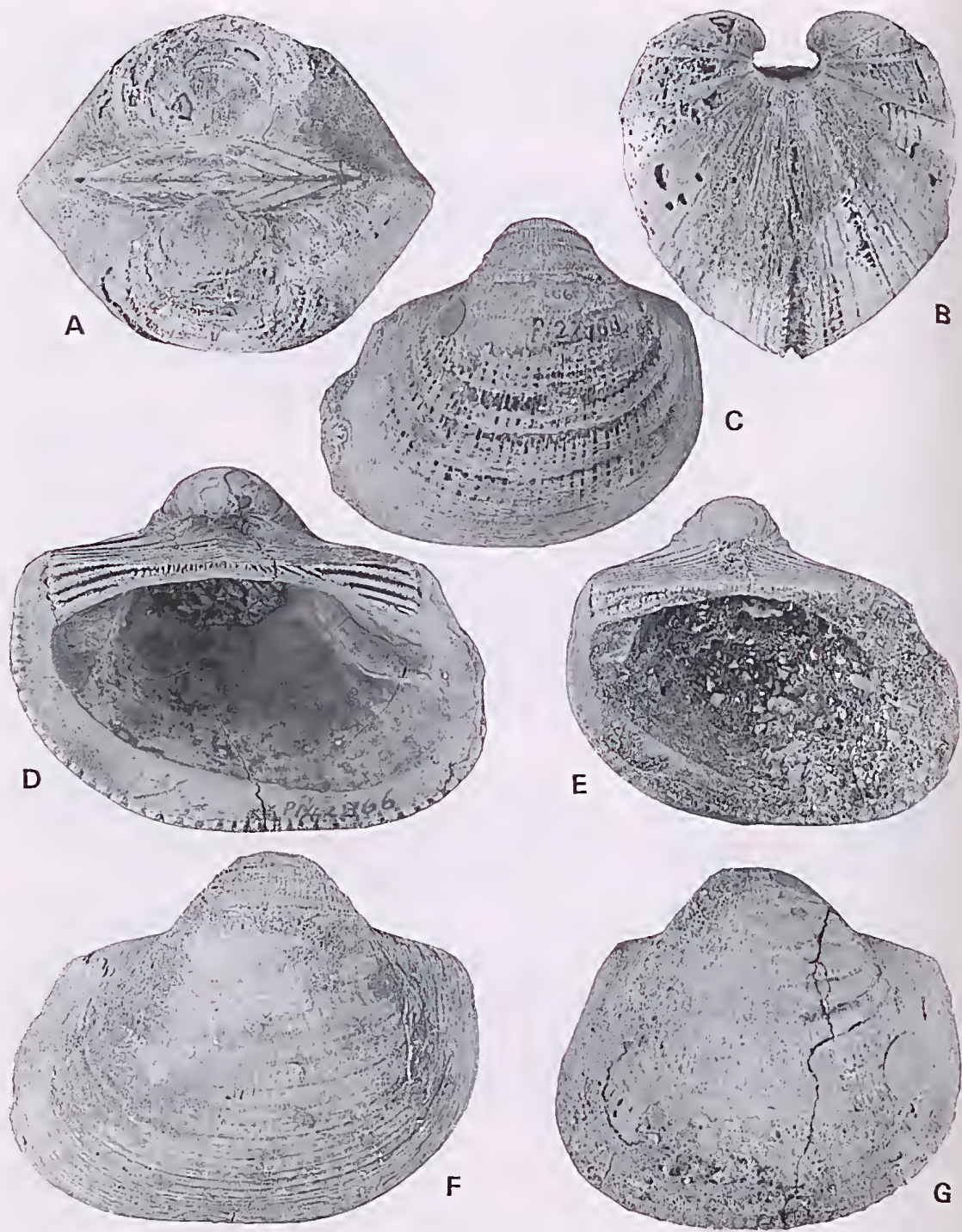


Fig. 2. A-G, *Cucullaea psepheia* Singleton. A-B, NMV P142865, PL3004,  $\times 1.2$ . C, E, NMV P127953, holotype, second point NW of Pebble Point,  $\times 1$ . D, F, NMV P142866, PL3004,  $\times 1.2$ . G, NMV P127954, paratype, second point NW of Pebble Point,  $\times 1$ .



## Family CUCULLAEIDAE

*Cucullaea* Lamarck, 1801

*Type species.* *Arca cucullata* Röding, 1798, Recent, Indo-Pacific.

Genera of the *Cucullaea* group are in need of revision, so I have placed *psephea* in *Cucullaea* (*sensu lato*). Either *Cucullona* Finlay & Marwick 1937 or *Latiarca* Conrad 1862 could be used if it was thought that there is sufficient justification to separate one or the other from *Cucullaea*. The hinge is similar to species of *Idonearca*, Late Cretaceous and Paleocene of North America, but the species in that genus all lack marginal denticulations.

Davies (1929) pointed out that *Cucullaea* was typical of the Boreal Paleocene of Europe and North America and the Paleocene of southern South America, i.e. that it had a bipolar distribution, and that it was absent from the Tethyan faunas of Africa and Asia. (See also Davies 1934, Fig. 9.) The Australian occurrence fits in with this pattern of distribution. The Recent distribution of *Cucullaea* is temperate to tropical. The Paleocene distribution should provide a note of caution in using the occurrence of *Cucullaea* in a fauna as evidence for warm water.

*Cucullaea* (s.l.) *psephea* Singleton, 1943

## Fig. 2A-G

*Cucullaea* (*Cucullona*) *psephea* Singleton 1943: 269, pl. 13, figs 7a-b, 8a-b.—Ludbrook 1973: pl. 24, figs 1, 3.

*Description.* Shell of medium size for the genus (60×47–35×32), thick, inequilateral, equivalve, strongly inflated, subquadrate, with large prominent incurved umbos. Radial sulcus running from umbo to posterior sinus situated at upper part of posterior margin. Exterior of valves almost smooth, sculpted with fine growth lines, somewhat undulose towards margin where they cross very faint radial ribs. When weathered, surface shows radial elements aligned with internal margin denticulations.

Ligamental area triangular, clongate with 7 to 12 deeply incised chevron grooves. Hinge heavy with subhorizontal, thick, grooved teeth at each end of hinge and with numerous coarse denticulations between the two groups of teeth. Three anterior teeth and in some specimens a weak fourth ventrally. Four to six posterior teeth on posterior side of left valve.

Adductor scars large, prominent. Anterior D shaped, somewhat vertically clongated. Posterior

D shaped, elongated laterally with prominent myophoric ridge ventrally.

Pallial line deeply incised. Internal margin coarsely denticulate.

On unweathered juvenile specimens, ubonal region sculptured with very narrow widely spaced ribs that correspond to the marginal denticulations. These flatten out and become less perceptible on mature specimens.

*Dimensions*

	L	H	VTh
Holotype P127953	59	51	27
Paratype P127954	40	36	15
Figured specimen P142865	52	44	42 pair
Figured specimen P123866	60	49	26

*Type material.* Holotype P127953 (MUGD 1869), right valve, Paratype P127954 (MUGD 1870), right valve, collected G. Baker, January 1942. Figured specimens P142865–6, PL3004, collected T. A. Darragh, 19 November 1970.

*Type locality.* Coastal cliffs 2½ miles south-east of Princetown, Victoria, from second point north-west of Pebble Point (= PL 3004).

*Occurrence and material.* PL3001 (29 specimens), PL3003 (28 specimens), PL3004 (37 specimens), PL3005 (7 specimens), PL3006 (1 specimen).

*Remarks.* Nearly all mature specimens are denticulated to some extent. As Singleton has pointed out, this species is very close to *Cucullaea inarata* Finlay & Marwick from Wangaloa. The sculpture is identical and the outline similar. *C. psephea* has more incurved umbos and hence is a little wider across the valves. A larger range of the former for comparison may show that the differences between the two are not consistent and that *Cucullaea psephea* is a synonym of *C. inarata*.

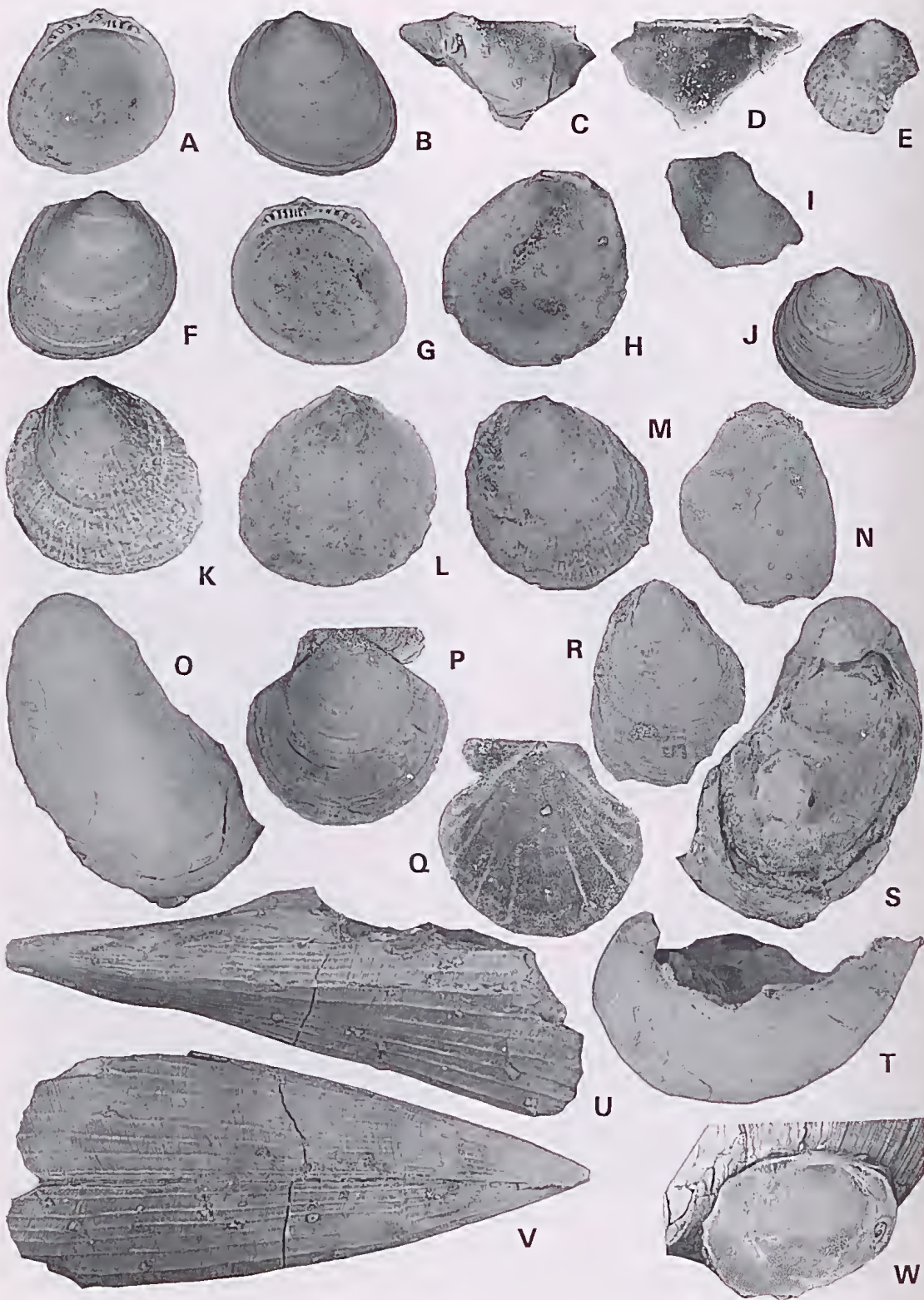
It is somewhat similar in sculpture to *C. ellioti* Zinsmeister & Macellari, Paleocene, Antarctica and to *C. antarctica* Wilckens, Late Cretaceous, Antarctica and Argentina, but these are not so equilateral as *C. psephea*. It is also close to *C. gigantea* Conrad, Paleocene, eastern United States of America but seems to be not so strongly ribbed.

*Cucullaea psephea* is closer to the other Southern Hemisphere species than to those of the Northern Hemisphere which mostly bear weak to strongly developed radial ribs.

## Family LIMOPSIDAE

*Limopsis* Sassi, 1827

*Type species.* *Arca aurita* Brocchi, 1814, Pliocene, Italy.





***Limopsis rupestris* sp. nov.**

Fig. 3A–B, F–G, J

*Limopsis* sp. nov. Singleton 1943: 271, pl. 12, fig. 2a, b.

**Description.** Shell roundly subquadrate, slightly oblique, of small to medium size ( $7 \times 7$ – $10 \times 11$ ) for the genus, solid, equivalve, moderately convex, inequilateral. Umbos small, pointed, extending beyond dorsal margin. Posterior and anterior dorsal margins short, straight; posterior margin straight or slightly concave; ventral margin convex, merging imperceptibly into anterior margin; anterior margin convex.

Hinge strongly arched; cardinal area triangular, low elongate with central triangular ligament pit encroaching slightly onto central hinge teeth. Right valve with 4 to 6 strong posterior teeth and 3 or 4 weak teeth in centre and 4 to 5 strong anterior teeth. Left valve with 4 to 6 strong posterior teeth, 2 to 3 weak teeth in centre and 4 to 5 strong anterior teeth.

Anterior muscle scars bounded ventrally by sharp ridge, small and obliquely elongated; posterior scar much larger, subtriangular. Internally valves radially striated to the pallial line. Internal valve margin smooth.

Surface of valve shiny, sculptured only with irregular growth striae and very faint (worn off on most specimens) radial striae.

**Dimensions**

Holotype P142871	L 7.2	H 7.2	T 2
Paratype P142872	7.5	7.5	2.5
Paratype P142873	6	6.5	2

**Types.** Holotype P142871, Paratypes P142872–3, collected T. A. Darragh, 27 November 1972.

**Type locality.** PL3003.

**Occurrence and material.** PL 3001 (38 specimens), PL 3003 (322 specimens), PL 3004 (34 specimens).

**Remarks.** This is one of the most common bivalves in the fauna. The outer surface of the valves is worn in most specimens. Articulated pairs are very rare. It is somewhat similar to *Limopsis chapmani* Singleton, Late Eocene and Oligocene of south-eastern Australia, particularly to the ecomorphs of that species from the Browns Creek

Clay, but the radial elements in *chapmani* are much stronger than those of *rupestris*. However, the latter may well be ancestral to the former.

It is quite unlike the New Zealand Paleocene *L. microps* (Finlay & Marwick 1937) which looks almost like a species of *Glycymeris*. *L. rupestris* is almost twice the size, oblique in shape and not almost equilateral as in the former. *L. antarctica* Wilckens, Late Cretaceous, Seymour Island is twice the size, more rounded and oblique in shape.

It seems similar to *L. ludbrookae* Glibert & Van der Poel, Paleocene, Europe, but that species is not so oblique, and also to *L. obesa* Ravn, Danian, Faxe, but that species is more rounded in outline.

There seems to be nothing similar recorded from North or South America.

**Family PINNIDAE*****Pinna* Linnaeus, 1758**

**Type species.** *P. rudis* Linnaeus, 1758, Recent, Atlantic.

***Pinna* sp.**

Fig. 3U–V

**Description.** Shell large (158+ mm), thin, wedge-shaped, equilateral, with a median carina giving a rhomboid cross section. Sculpture consisting of fine radial costae, much narrower than interspaces, becoming broader posteriorly; left valve with 11 to 12 ribs (8 ribs on dorsal side of median carina) plus wavy irregular ribs on anterior ventral portion of valve. Right valve with 11 ribs (7 ribs on dorsal side of median carina). Internal features of valves not visible.

**Figured material.** Figured specimen P142868, collected T. A. Darragh and D. J. Holloway, 23 November 1992.

**Occurrence and material.** PL3003 (2 specimens), PL3004 (1 specimen), PL3176 (1 specimen).

**Remarks.** There are four specimens available; a large, slightly crushed pair, 158+ mm in length (P142868); a fragmentary pair (P142869, length 96 mm), a fragmentary right valve (P142870) and a fragmentary valve.

Fig. 3. A–B, F–G, J, *Limopsis rupestris* sp. nov. A–B, NMV P142871, holotype, PL3003,  $\times 3.5$ . F–G, NMV P142872, paratype, PL3003,  $\times 3.5$ . J, NMV P142873, paratype, PL3003,  $\times 3.6$ . C–D, I, *Electroma* sp. C–D, NMV P142965, PL3003,  $\times 6.4$ . I, NMV P142966, PL3003,  $\times 6.6$ . E, limid. NMV P142881, PL3003,  $\times 7.5$ . H, K–M, *Anomia* sp. H, M, NMV P142878, PL3003,  $\times 3.6$ . K–L, NMV P142879, PL3003,  $\times 3.4$ . N–O, R–T, W, *Pychodonte* (*Phygraea*) sp. N, R, NMV P142885, PL3004,  $\times 1.8$ . O, S–T, NMV P142887, PL3001,  $\times 1.5$ . W, NMV P142888, PL3003,  $\times 1$ . P–Q, *Parvamussium* cf. *P. hauniense* Ravn. NMV P142874, PL3003,  $\times 1.6$ . U–V, *Pinna* sp. NMV P142868, PL3004,  $\times 0.6$ .

As far as comparison is possible on the basis of this limited material, it is very similar in morphology to *Pinna sobrali* Zinsmeister, Late Eocene, Meseta Formation, Seymour Island and also to *P. burrowsi* Dickerson, Late Paleocene, California. Fragmentary specimens of a pinnid from the Late Oligocene Jan Juc Formation, Torquay, seem to be more hatchet-shaped rather than wedge-shaped and probably belong in *Atrina*.

#### Family PTERIIDAE

##### *Electroma* Stoliczka, 1871

*Type species.* *Avicula smaragdina* Reeve, 1857, Recent, Indonesia.

*Pterelectroma* Iredale 1939: 332.

##### *Electroma* sp.

Fig. 3C-D, 1

*Description.* Shell small (juveniles), thin, nacreous, oblique; anterior with a triangular wing separated from flank of valve by slight sinus. Umbo projecting slightly above hinge line, opisthogyral. Hinge long and straight with triangular posteriorly directed resilifer pit under umbo, slightly anterior of mid point of hinge. Hinge with long posterior lateral and one very short anterior lateral. Internal features of valve not preserved. External surface of valve smooth.

##### *Dimensions*

Figured specimen P142966	L 1.4	H 1.2
Figured specimen P142965	4.5 +	2.5 +

*Figured material.* Figured specimens P142965-6, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3003 (7 left valves).

*Remarks.* All five specimens are small and the two smallest are almost certainly juveniles. Only two valves are sufficiently complete and large enough for comparison with other taxa. It seems similar to Paleogene species assigned to *Electroma* Stoliczka, though *Pteria* has also been used for such species and may well be the correct taxon.

The anterior of the valve is slightly more produced than in juveniles of *Electroma georgiana* (Quoy & Gaimard), living, southern Australia and the central part of the valve is much more convex (higher). In this respect it is somewhat similar to *Electroma zebra* (Reeve), Recent, Queensland, type species of *Pterelectroma* Iredale, 1939. *Pterelectroma* was separated from *Electroma* on the basis of the former being smaller and thinner and having a definite posterior wing separated from the body. Comparison of specimens of *E. zebra*

and *E. georgiana* shows that the development of the posterior wing is highly variable in both species and this cannot be used as a generic character to separate *Pterelectroma*.

In shape the Pebble Point species is similar to *Electroma stampinensis* (Deshayes), Early Oligocene, Europe, but is not so oblique as other Eocene taxa assigned to *Electroma* by Glibert & Van der Poel (1965). It has a smaller anterior wing and is more rectangular in shape than *E. intacta* Finlay & Marwick, Wangaloan, New Zealand. *E. notiala* Stilwell & Zinsmeister, Late Eocene, Seymour Island, is much more oblique than the Pebble Point taxon. Despite the difficulty of determination of the Pebble Point material, it is clear that the Pebble Point taxon belongs to a group that was widespread in the early Paleogene.

#### Family PROPEAMUSSIIDAE

##### *Parvanusium* Sacco, 1897

*Type species.* *Pecten duodecimlamellatum* Bronn, 1831, Miocene, Italy.

##### *Parvanusium* sp. cf. *P. hauniense* Ravn, 1939

Fig. 3P-Q

*Description.* Shell small, thin, subcircular in outline, flat. Right ears unequal, with byssal notch in anterior ear. Sculpture of left valve consisting of very fine, regular, closely spaced, shallow grooves; right valve worn, all traces of sculpture removed. Internally sculptured with widely spaced, high, narrow radial costae extending almost to valve margin (10 in RV and 8 in LV).

##### *Dimensions*

Figured specimen P142874	L 8.5	W 8.5	RV
Figured specimen P142875	5.8	6.0	LV

*Figured material.* Figured specimen P142874, collected T. A. Darragh, 13 November 1984.

*Occurrence.* PL3001 (1 specimen), PL 3003, (5 specimens), PL3004 (1 specimen).

*Remarks.* The left valve of *P. hauniense* Ravn, Paleocene of Denmark and Germany (Anderson 1973) is similar in shape and sculpture, however, the eroded condition of the right valve of the Pebble Point taxon precludes any close comparison with any other species in the genus.

*Parvanusium* occurs in the Paleocene in Europe and western and south-eastern United States. As yet there are no records from the Paleocene of New Zealand, Antarctica or South America. *P. atkinsoni* Johnstone of the Late Eocene to Middle Miocene of southern Australia has a similarly



sculptured left valve and a right valve with reticulate sculpture.

Family ANOMIIDAE

*Anomia* Linnaeus, 1758

*Type species.* *Anomia ephippium* Linnaeus, 1758, Recent, Europe.

*Anomia* sp.

Fig. 3H, K-M

*Description.* Shell small ( $8 \times 10$ – $13.5 \times 14$ ), thin, translucent, irregularly sub-circular to elliptical in outline, slightly higher than wide, inequilateral. Left valve moderately convex, sculptured with narrow, widely separated radial ribs. Umbo small, pointed. In most cases left valve margin leached away in front of umbo (byssal notch area?). Right valve flat, internal features not known. Left valve central white area elongate, individual muscle scars not visible owing to poor preservation. Small anterior pedal retractor scar visible. Umbonal area missing in most cases. Outer surfaces of most valves either worn or outer and inner surfaces leached away. A few specimens show coarse, beaded (scabrose?) radial ribs.

*Dimensions*

Figured specimen P142878 L 7.8 H 9 T 1.5

Figured specimen P142879 8.2 9 2

*Figured material.* Figured specimens P142878–9 collected T. A. Darragh, 2 December 1985.

*Occurrence and material.* PL3001 (53 specimens), PL3003 (28 specimens).

*Remarks.* The genus has a wide but patchy distribution in the early Tertiary, occurring in western and eastern Europe, eastern and western United States of America, Central America and New Zealand. Owing to the poor preservation, it is difficult to compare the Pebble Point specimens with those from other regions.

Family LIMIDAE

Limid indet.

Fig. 3E

*Description.* Shell small ( $2+ \times 2.5$  mm), equilateral?, oval, slightly higher than wide; umbo somewhat inflated, orthogyral, projecting very slightly above hinge margin; auricles small, subequal. Approximately 30 radial ribs, thin and crowded on anterior and posterior flanks, broad and widely spaced on central flank. Ligamental area, centrally situated, triangular; teeth if present,

not visible but some faint vertical striations present. Internal features of valves eroded.

*Dimensions*

Figured specimen P142881 L 2.4 (est.) H 2.3+

*Figured material.* Figured specimen P142881, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3001 (1 specimen); PL3003 (1 specimen); PL3004 (1 specimen).

*Remarks.* The three specimens are all worn and fragmentary. One specimen is partly decorticated. Owing to the poor preservation of the three specimens, it is not possible to be certain of the generic placement. The taxon may be a *Limatula*, if it is edentulous; if not then a *Linea*, though it seems to be almost equilateral rather than produced anteriorly as in that genus. However, all specimens are probably juveniles and may not show the outline of the mature shell.

Family GRYPHEIDAE

*Pycnodonte* (Phygraea) Vyalov, 1936

*Type species.* *Pycnodonte* (Phygraea) *pseudovesicularis* Gümbel 1861, Paleocene, Austria.

*Pycnodonte* (Phygraea) sp.

Fig. 3N–O, R–T, W

*Description.* Shell gryphaeiform, elongate, small for genus ( $34 \times 25$ – $39 \times 21$ ), slightly to strongly oblique, attachment area small to large; left valve highly inflated and incurved, with prominent commissural shelf on dorsal half of valve; chomata simple transverse bars, few on anterior side, close to hinge, many on posterior side extending along commissural shelf well away from hinge; sinus not very well developed. Right valve flat to slightly concave, with very weakly developed chomata. Sculpture of fine growth lines.

*Dimensions*

Figured specimen P142885 W 14 H 18

Figured specimen P142887 20 35

Figured specimen P142888 29 23

*Figured material.* Figured specimen P142885, collected T. A. Darragh, 20 October 1971; Figured specimen P142887, collected T. A. Darragh, 16 February 1981; Figured specimen P142888, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3001 (1 specimen), PL3003 (2 specimens), PL3004 3 specimens.

*Remarks.* This species comes closest to specimens of *Pycnodonte* (Phygraea) sp. cf. *P. vesiculosa* (Sowerby, 1816) figured by Zinsmeister (1988) from





the Late Cretaceous of Seymour Island, Antarctica. Zinsmeister noted that his specimens lacked the radial posterior furrow typical of the species.

Somewhat similar specimens were figured by Pantelev (1974) as *Pycnodonte frauscheri* Traub from the Early Paleocene of the Mangyshlak district of the eastern side of the Aral Sea.

The Pebble Point taxon bears some resemblance to *Pycnodonte* (*Notostrea*) *tarda* (Hutton) Paleocene, New Zealand and *P. (N.) lubra* (Finlay), Late Eocene, southern Australia, but it is narrower and more ineurved, not so produced posteriorly and lacks the radial posterior furrow that separates the posterior from the rest of the valve.

*Pycnodonte* (*Phygraea*) has a cosmopolitan distribution ranging in age from Cretaceous to Miocene. Darragh & Kendrick (1991) discussed the Late Cretaceous and Paleocene representatives in north-west Western Australia, from which the Pebble Point taxon may be descended.

Two specimens from locality PL3003 are attached to other shells. P142888 is attached to the posterior flank of a right valve of *Latillia australica*. The growth of the oyster suggests that it became attached after the valves of the *Latillia* had become separated and the right valve lay on the bottom, rather than whilst the *Latillia* was still living. The second oyster, P142889, is attached close to the ventral margin of a specimen of *Cucullaea psepheia* and must have become attached after the death of the *Cucullaea*. P142888 has a few transverse barlike chomata on the commissural shelf close to the hinge. This specimen, though attached, seems similar in internal features to the three unattached specimens and I believe represents the same taxon. It is very similar to the specimen attached to a specimen of *Pycnodonte* (*Phygraea*) *seymourensis* figured by Zinsmeister (1988, Fig. 11.1).

#### Family TRIGONIIDAE

##### *Eotrigonia* Cossmann, 1912

*Type species.* *Trigonia seniuundulata* McCoy, 1866 (= *T. subundulata* Jenkins, 1865).

##### *Eotrigonia paleocenica* Darragh, 1986

Fig. 4R-S

*Eotrigonia paleocenica* Darragh 1986: 10, Figs 4G, 1-L, N, 5A-B.

#### *Dimensions*

Figured specimen P142959 W 11 H 9

*Figured material.* Figured specimen P142959, collected T. A. Darragh, 2 December 1985.

*Occurrence and material.* PL3001, PL3003, PL3004.

*Remarks.* This taxon was fully described in the original description. Since then another 15 specimens have been collected which add nothing new to the concept of the species.

#### Family LUCINIDAE

##### *Jagolucina* Chavan, 1939

*Type species.* *Lucina concava* Defrance, 1823, Eocene, France.

##### *Jagolucina* ? sp.

Fig. 4E, G

*Description.* Shell subcircular, of average size (6-10 mm), moderately inflated; umbo pointed, prosogyral; anterior dorsal margin concave; anterior, ventral and posterior margins regularly convex, not differentiated from one another; posterior dorsal margin straight. Lunule short, prominent. Sculpture of fine, close-set, commarginal ribs.

*Hinge:* left valve with bifid anterior cardinal; thin posterior cardinal; two anterior laterals separated by short socket; possibly one posterior lateral.

Anterior muscle scar long, narrow, divergent from pallial line, extending from under anterior lateral tooth well into valve. Posterior scar lozenge-shaped, not clearly visible.

Internal margin of shell smooth.

#### *Dimensions*

Figured specimen P142890 L 6.5 H 6

Figured specimen P142891 11.2 10.5

*Figured material.* Figured specimen P142890, collected T. A. Darragh, 13 November 1984.

Fig. 4. A-D, F, *Cyamiocardium silicula* sp. nov. A-B, NMV P142904, paratype, PL3003,  $\times 8.1$ . C-D, NMV P142902, holotype, PL3003,  $\times 8.1$ . F, NMV P142903, paratype, PL3003,  $\times 15$ . E, G, *Jagolucina* ? sp. NMV P142890, PL3003,  $\times 4.75$ . H-K, *Astarte notialis* sp. nov. H-I, NMV P142900, holotype, PL3003,  $\times 1.8$ . J-K, NMV P142901, paratype, PL3003,  $\times 5$ . L-M, *Fellaniella* (*Zenysia*) sp. NMV P142897, PL3003,  $\times 3.4$ . N-O, *Borniola* ? sp. N, NMV P142899, PL3003,  $\times 8.5$ . O, NMV P142899,  $\times 5.5$ . P-Q, *Thyasira* sp. P, NMV P142949, PL3003,  $\times 6.75$ . Q, NMV P142949,  $\times 4.5$ . R-S, *Eotrigonia paleocenica* Darragh. NMV P142959, PL3003,  $\times 3.25$ .

*Occurrence and material.* PL3001 (one left valve), PL3003 (8 left and one right valve).

*Remarks.* All specimens are very worn and the generic position is very much open to doubt. Three of the left valves have gastropod boreholes. I have found no obviously related species in the southern hemisphere. *Jagolucina* occurs in the Paleocene and Eocene of Europe.

#### Lucinid indet. sp. A

This species is represented by a single right valve P142940, probably juvenile, measuring  $2.3 \times 2.0$ . The hinge is edentulous and there is a groove running from behind the umbo towards the posterior. Sculpture consists of growth lines only. It has not been possible to determine to what genus the taxon belongs. It is possibly an *Anodontia* or some other similar smooth edentulous lucinid.

#### Lucinid indet. sp. B

*Description.* Shell small ( $6.3 \times 5.7$ – $9.5 \times 8.5$  mm), weakly inflated; umbo small, pointed, orthogyral; posterior dorsal margin straight; posterior margin almost straight, somewhat truncating posterior dorsal margin; ventral and anterior margins convex, merging imperceptibly; anterior dorsal margin concave; lunule deeply sunken. Sculpture of widely separated, thin commarginal lamellae.

Hinge: left valve with strong triangular anterior cardinal; thin posterior cardinal separated from anterior cardinal by narrow triangular socket. Posterior laterals formed from valve margin (valve worn and not well preserved). Right valve with weak anterior cardinal? (worn); central triangular socket; posterior cardinal strong, blade-like; short, stout (worn) anterior and posterior laterals; short sockets dorsal to these.

Margins of valves smooth. Muscle scars and pallial line not observed.

*Material.* PL3001 (1 right valve); PL3003 (2 right valves); PL3004 (1 left valve).

*Remarks.* Owing to the limited nature of the material and its poor preservation it has not been possible to assign this species to a genus. Two specimens are incomplete and worn and the possibility exists that they do not belong in the same taxon as the others.

#### Myrtea Turton, 1822

*Type species.* *Venus spinifera* Montagu, 1803, Recent, Mediterranean.

#### *Myrtea fascolata* sp. nov.

Fig. A–G

*Description.* Shell small ( $4 \times 3.5$  mm– $5 \times 6.5$ ), elongate, oval, moderately inflated; umbo small, pointed, situated at posterior third; posterior and anterior dorsal margins concave; posterior margin straight, abruptly truncating the posterior dorsal and ventral margins; anterior margin strongly convex, merging imperceptibly into ventral margin; ventral margin regularly convex. Sculpture of widely spaced, well developed commarginal lamellae, slightly frilled on anterior of flank.

Hinge: right valve with short strong anterior lateral; single central cardinal flanked by two deep triangular sockets; posterior lateral, short, stout; anterior and posterior laterals flanked on dorsal side by sockets. Left valve with two stout central cardinals separated by deep socket, anterior cardinal larger than posterior; anterior and posterior laterals short, formed from extension of valve margin, each flanked ventrally by deep socket.

RV 01 010 10 →  
LV 10 101 01 ←

Anterior muscle scar elongate, narrow, kidney shaped. Posterior scar kidney shaped, slightly narrower than anterior scar. Pallial line entire. Internal valve margins smooth.

#### *Dimensions*

Holotype P142952	L 3.2	H 2.5
Paratype P142893	4.1	3.5
Paratype P142953	3 +	2.9 +
Paratype P142964	2.7	2.2

*Type material.* Holotype P142952, Paratype P142953, Paratype P142964, collected T. A. Darragh, 24 November 1992; Paratype P142893, collected T. A. Darragh, 17 February 1981.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (1 specimen); PL3003 (12 specimens).

*Remarks.* This species is characterised by the posterior section of the valve being larger than the anterior. The genus has a widespread distribution, occurring in North America from the Eocene and in Europe from the Miocene, but seems to have been recorded from the Paleocene only in New Zealand [*Myrtea microlirata* (Finlay & Marwick)]. *M. faseolata* has similar sculpture to *M. microlirata*, but is very much smaller, more elongate and the posterior section of the valve is relatively smaller. In addition the genus occurs from Late Oligocene to Early Pliocene in New Zealand. It is recorded from Late Pliocene to Recent in Australia.



## Family THYASIRIDAE

**Thyasira** Leach, 1818

*Type species.* *Venus flexuosa* Montagu, 1803, Recent, Mediterranean.

**Thyasira** sp.

## Fig. 4P-Q

*Description.* Shell thin, somewhat globose, sub-circular, of average size for genus; umbo pointed, strongly prosogyral; lunule broad sunken. Anterior dorsal margin concave, anterior and ventral margins continuous, regularly convex; posterior dorsal and posterior margins convex continuous. Shallow sulcus running from umbo to posterior margin and forming notch in posterior margin. Ridge (sub-marginal sulcus) running from umbo parallel and close to posterior dorsal margin. Hinge plate edentulous. Sculpture of growth striae only.

*Dimensions*

Figured specimen P142949      L 7.2      H 7.2

*Figured material.* Figured specimen P142949, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3003 (2 specimens).

*Remarks.* Both specimens are left valves. This taxon is very close to the type species of the genus in shape and hinge. It is somewhat similar to *Thyasira* (*Parathyasira*) *resupina* Iredale, Recent, New South Wales, but lacks the fine radial sculpture of that species. It is also somewhat similar to *T. (P.) notosulcata* Stilwell & Zinsmeister, late Eocene, Seymour Island. The genus is found in the Paleocene of Europe but is uncommon. It has not yet been recorded from the early Tertiary of the United States of America or New Zealand.

Kauffman (1969) suggested that fossil species of *Thyasira* had similar environmental requirements as the living species which have their greatest diversity in temperate waters and are not common in Arctic, Antarctic and tropical seas. He presented data that suggested that the present species would not be found with such a diversity of generic taxa as in the Pebble Point assemblage as a whole but some of the associated taxa would be found with it, e.g. *Propeamusium*, *Astarte* and *Cuspidaria*.

## Family UNGULINIDAE

**Felaniella** (*Zemysia*) Finlay, 1926

*Type species.* *Lucina zelandica* Gray, 1835, Recent, New Zealand.

**Felaniella** (*Zemysia*) sp.

## Fig. 4L-M

*Description.* Shell subquadrate, of average size for the genus (10×10 mm), almost equilateral; umbo scarcely projecting, orthogyral; anterior dorsal margin straight; anterior margin straight; ventral margin slightly convex; posterior margin slightly convex; posterior dorsal margin straight. No lunule or escutcheon. Sculpture of growth ridges only.

Hinge: left valve with long anterior lateral socket; stout central bifid cardinal, wide triangular socket posterior to it; posterior cardinal blade-like; long ligament groove.

Anterior muscle scar dorso-ventrally elongate, somewhat irregular, slightly larger than posterior scar; posterior scar slightly irregular in shape, dorso-ventrally elongate. Pallial line entire, deeply impressed. Internal margins of valve smooth.

*Dimensions*

Figured specimen P142897      L 1      H 1

*Figured material.* Figured specimen P142897, collected T. A. Darragh, 18 November 1984.

*Material.* PL3003 (two left valves).

*Remarks.* This has some resemblance to the type species, *Zemysia zelandica*, but the Pebble Point specimen is more quadrate, not so inflated and is higher than wide. It is close to *F. (Z.) elliptica* (Lamarck), Late Eocene, Paris Basin.

The subgenus has a wide distribution; the earliest records being in the Paleocene of Europe. In the southern hemisphere it is known from the Late Eocene and Miocene to Recent of New Zealand and the Recent of Australia. It has not been recorded as a fossil in Antarctica.

## Family ERYCINIDAE

**Borniola** Iredale, 1924

*Type species.* *Bornia lepida* Hedley, 1906, Recent, New South Wales.

**Borniola** ? sp.

## Fig. 4N-O

*Description.* Shell triangular, of average size for the genus; umbo pointed, slightly projecting, slightly prosogyral; valve strongly convex at flanks, central part of the disk flattened or slightly depressed; posterior dorsal margin straight, posterior and anterior margins short, strongly convex; ventral margin slightly concave.

Hinge with prominent socket posterior to long posterior tooth; central triangular resilifer; anterior tooth strong, projecting, hooked towards posterior at dorsal end, flanked on anterior by narrow socket. Muscle scars subequal, situated high in valve. Pallial line entire. Sculpture of growth lines only.

#### Dimensions

Figured specimen P142899 L 4.1 H 3.5

*Figured material.* Figured specimen P142899, collected T. A. Darragh, 13 November 1984.

*Occurrence and material.* PL3003 (one left valve).

*Remarks.* The specimen resembles specimens of *Borniola reniformis* (Suter 1909), type species of the genus *Rochefortula* Finlay, 1927 (synonymised with *Borniola* by Ponder, 1967 but the reasons have not yet been published). The Pebble Point specimen is more trigonal, the resilium pit is much wider, the teeth diverge more, and the sockets are narrower. The genus is known from the Early Miocene to Recent of New Zealand and Recent of Australia. *Mysella trigonoelliptica* Stilwell & Zinsmeister, Late Eocene, Antarctica, may be a related taxon.

### Family CYAMIIDAE

#### Cyamiocardium Soot-Ryen, 1951

*Type species.* *Cyamium denticulatum* Smith, 1907, Recent, Antarctica.

#### Cyamiocardium silicula sp. nov.

Fig 4A–D, F

*Description.* Shell roundly subquadrate, small (4–7 mm). Umbo broad, prosogyral, not projecting; posterior dorsal margin almost straight, merging rather abruptly with posterior margin; posterior margin gently curved merging imperceptibly with curved ventral margin; ventral margin merging imperceptibly with anterior margin; anterior dorsal margin straight, merging rapidly with curved anterior margin.

Sculpture of irregular growth striae and prominent growth interruptions. On unworn specimens very weak, low, broad radial ribs visible, ribs broader than interspaces.

Hinge: left valve with large, stout, bifid central cardinal, flanked by wide triangular sockets; sockets each flanked by blade-like teeth, posterior tooth much thinner and encroached upon by resilifer; wide resilifer between posterior tooth and valve margin. Right valve with two curved, strong blade-like cardinals, diverging from umbo,

separated by wide triangular socket and flanked by narrow deep sockets; posterior socket contiguous with resilifer on posterior side.

RV 01010 →  
LV 10A01

Anterior muscle scar D shaped, elongate, slightly smaller than posterior, both situated high in valve. Pallial line entire. Internal margin of valves weakly denticulate.

#### Dimensions

Holotype P142902	L 3.7	H 3.4
Paratype P142903	4.2	3.6
Paratype P142904	4.0	3.7

*Type material.* Holotype P142902, collected T. A. Darragh, 27 November 1972; Paratypes P142903–5, collected T. A. Darragh, 13 November 1984.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (7 specimens), PL3003 (49 specimens), PL3004 (8 specimens).

*Remarks.* Most specimens are worn, suggesting transport and few specimens show the external radial sculpture and the marginal denticulations. Specimens are fragmentary as they easily break at the prominent growth interruptions. Two specimens have countersunk gastropod boreholes.

The family is comprised mostly of genera occurring in the southern hemisphere and has a very poor fossil record. *Cyamiocardium* is known living from Antarctica, Chile and Australia. *C. denticulatum* (Smith) has a circum Antarctic distribution in depths from 5 to 1180 m. *C. silicula* is very similar to the latter, but is more quadrate and the radial sculpture is broader. It is not so equivalve as *C. dahl* Soot-Ryan and the umbo is directed more to the anterior. The sculpture seems similar to that of *C. dahl*.

### Family ASTARTIDAE

#### Astarte (Astarte) J. Sowerby, 1816

*Type species.* *Venus scotica* Maton & Rackett, 1807, Recent, Scotland.

#### Astarte (Astarte) notialis sp. nov.

Fig. 4H–K

*Description.* Shell small (4–9), robust, trigonal to subquadrate. Umbos prosogyral, pointed. Posterior dorsal margin straight; posterior margin gently curved, merging imperceptibly into ventral margin; ventral margin gently convex; anterior margin strongly convex; anterior dorsal margin



straight or slightly concave. Escutcheon long, narrow, deep, sharply differentiated from valve surface. Lunule well developed, deep, lenticular, sharply differentiated from valve surface.

Hinge: left valve with anterior dorsal margin developed into an elongate lateral tooth; two thick cardinals separated by central triangular socket; elongate socket parallel to posterior dorsal margin. Right valve with elongate socket parallel to anterior dorsal margin; single strong, triangular central cardinal flanked by two deep triangular sockets and strong, elongate posterior lateral developed from posterior dorsal margin.

RV 1 n010 0 →  
LV 0 n101 1

Adductor muscle scars deeply impressed, subequal; anterior D shaped; posterior muscle scar, slightly smaller than anterior, subcircular. Anterior pedal retractor scar immediately posterior to anterior adductor scar; dorsal pedal retractor scar beneath umbo in deep circular pit; posterior retractor scar contiguous with dorsal side of posterior adductor scar. Pallial line entire, deeply impressed. Internal margin of valves denticulate.

Sculpture close to umbo on some specimens of 9–10 sharp, commarginal ribs; on others rather coarse, wide ribs close to umbo; remainder of valve with widely spaced, very coarse growth rugae.

#### Dimensions

Holotype P142900	H 7.5	W 6.5	T 2.0
Paratype P142901	5.5	5.2	

*Type material.* Holotype P142900, collected T. A. Darragh, 8 March 1977; Paratype P142901, collected T. A. Darragh, 2 December 1985.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (25 specimens), PL3003 (267 specimens), PL3004 (27 specimens).

*Remarks.* On most specimens, particularly the larger, the fine sculpture near the umbo is abraded off. This is the most common bivalve in the fauna. Only two articulated pairs are known, all others are single valves. Many valves have gastropod boreholes.

*Astarte notialis* sp. nov. is similar to many species of *Astarte* from the Oligocene of Europe, such as *A. (A.) gracilis* Münster, which also have the cardinal teeth reduced in number. The European species all have regular sharp, well developed commarginal ribs unlike *A. notialis*.

Species of *Astarte* are not common in Paleocene strata. They occur in England, Denmark and Ukraine, but not in Belgium and France, and probably not in the Paleocene of North America. From Oligocene time on the genus is widespread in Europe through to Recent. It seems characteristic

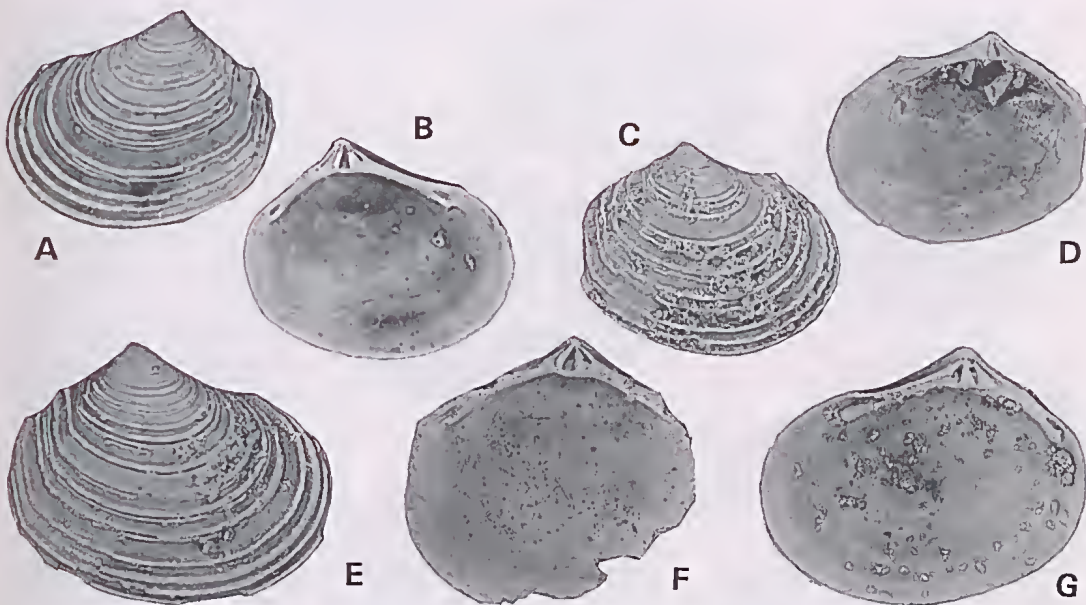
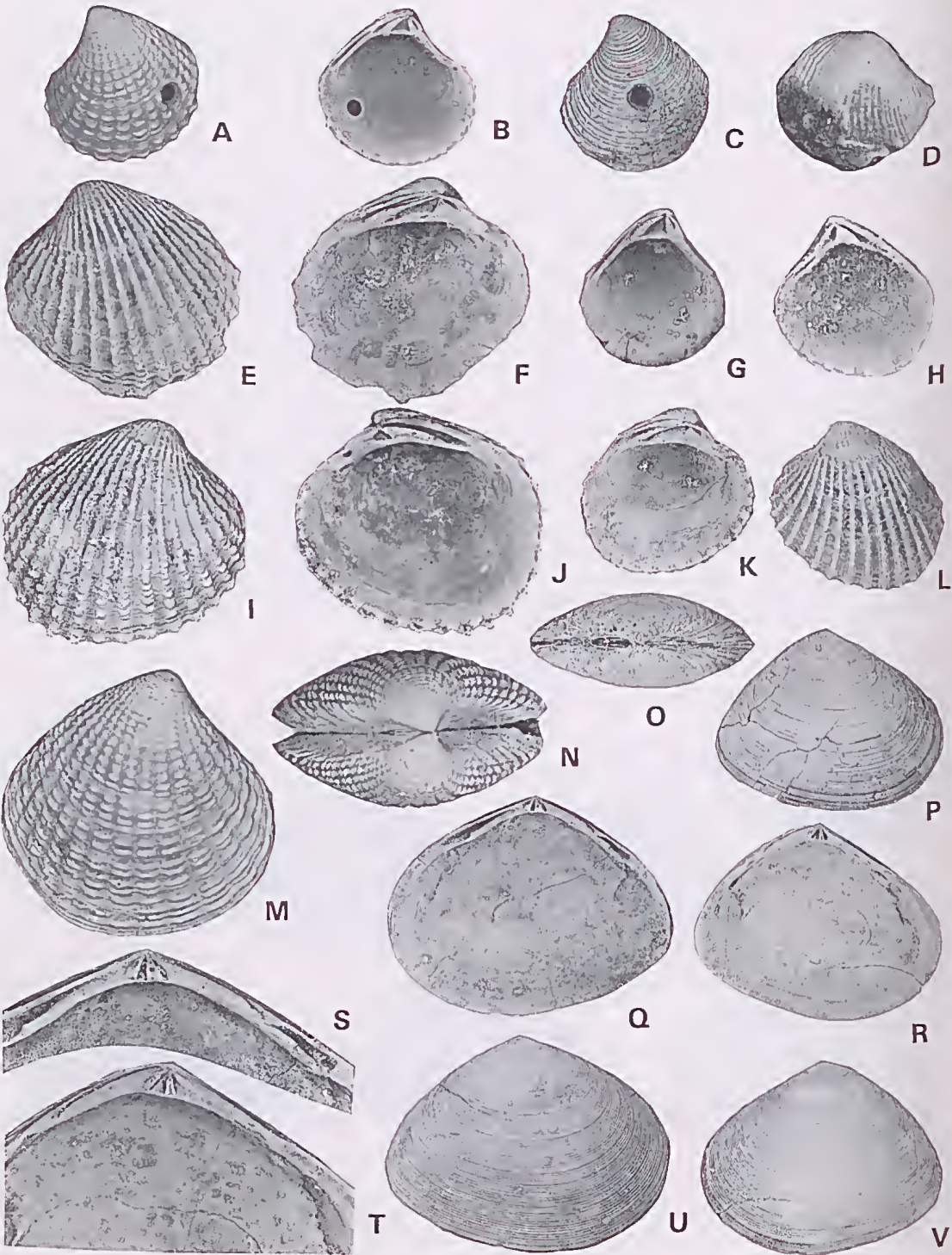


Fig. 5. A–G, *Myrtea faseolata* sp. nov. A–B, NMV P142964, paratype, PL3003,  $\times 12.6$ . C–D, NMV P142893, paratype, PL3003,  $\times 8$ . E, G, NMV P142952, holotype, PL3003,  $\times 12.8$ . F, NMV P142953, paratype, PL3003,  $\times 12.3$ .





of cool water. The only other records of *Astarte* in the southern hemisphere are *Astarte longirostris* d'Orbigny and *A. antarctica* Thiele from waters surrounding the Antarctic, where they are abundant. The genus is not found in Australia above the Paleocene and it is not known from New Zealand or the Early Tertiary in Antarctica.

#### Family CARDITIDAE

##### *Venericardia* (*Rotundicardia*) Heaslip, 1968

*Venericardia* (*Fasciculicardia*) Maxwell 1969: 173.

*Type species.* *Venericardia rotunda* Lea, 1833, Eocene, south-eastern United States of America.

Early representatives of this group are common in the Tertiary of south-eastern Australia and New Zealand and received the name *Fasciculicardia* Maxwell, 1969 (type species, *Venericardia subintermedia* Suter 1917, Miocene, New Zealand). Maxwell (1992) pointed out that *Fasciculicardia* resembled the North American *Rotundicardia*, but that species of the former are more elongated anteroposteriorly and have a posterior truncation. On comparing specimens of *R. rotunda* with *F. latissima* (Tate), Late Eocene, Australia, the only differences seem to be shape, as the hinges are identical. The latter species tends to be not so rounded as the former, having a 'sharper' anterior end, but some specimens are as rounded as specimens of *rotunda*. For these reasons I prefer to use *Rotundicardia*, regarding *Fasciculicardia* as a synonym until a major revision of the New Zealand and Australian taxa provides firmer distinctions between them and the North American group.

The new species described here, *Venericardia* (*Rotundicardia*) *petraea* sp. nov. is more rounded than most of the younger species attributed to *Fasciculicardia* and in this respect is similar to species of *Rotundicardia*. The hinge seems to be identical to the latter.

The hinge of similarly sculptured members of the family in the Paris Basin seems to have a different arrangement of hinge teeth and they are probably not closely related to Australian and American species. The group is not known in the Antarctic.

##### *Venericardia* (*Rotundicardia*) *petraea* sp. nov.

Fig. 6E–F, I–L

*Description.* Shell solid, equivalve, tumid, subrectangular; umbones scarcely projecting, strongly prosogyral; anterior dorsal margin short, straight, posterior and ventral margins gently convex, anterior margin more strongly convex. Lunule small, well developed, heart shaped, sunken. Sculpture of 21 to 26 strong radial costae, narrower than interspaces, bearing prominent tubercles, in many specimens tubercles produced into prominent spines or scales. On some specimens costae flanked on either side by a weaker ridge.

Hinge in left valve, with long narrow posterior socket flanked ventrally by long blade-like posterior tooth; large triangular socket in front of it; small stout triangular almost peglike tooth under umbo directed vertically and immediately anterior to it a small socket.

Right valve hinge with small deep anterior socket and short weakly developed, bladelike tooth dorsal to it; narrow central triangular socket posterior to it; prominent central triangular tooth directed anteriorly with long narrow deep socket posterior to it, widening ventrally and flanked dorsally by a stout, long, narrow posterior tooth.

RV 101010 →

LV 010101

Anterior adductor muscle scar oval, elongate dorso-ventrally. Posterior muscle scar subtriangular. Interior margin of valve strongly denticulate.

##### *Dimensions*

Holotype P142906	L 10	W 9	T 3.5
Paratype P142907	11	11	4
Paratype P142908	9.5	9	3.5

*Type material.* Holotype P142906, collected T. A. Darragh, 17 February 1981; Paratype P142907, collected T. A. Darragh, 8 May 1979; Paratype P142908, collected T. A. Darragh, 19 November 1970.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (25 specimens), PL3003 (54 specimens), PL3004 (3 specimens).

*Remarks.* Only one specimen is an articulated

Fig. 6. A–C, G–H, M–N, *Carditellopsis bellissima* sp. nov. A–B, NMV P142911, paratype, PL3003, showing gastropod borehole,  $\times 7.75$ . C, NMV P142968, paratype, PL3003, showing gastropod borehole,  $\times 6$ . G, NMV P142969, paratype, PL3003,  $\times 6$ . H, NMV P142915, paratype, PL3003,  $\times 6$ . M–N, NMV P142910, holotype, PL3003,  $\times 8$ . D, *Verticordia* sp. NMV P142950, PL3004,  $\times 3.5$ . E–F, I–L, *Venericardia* (*Rotundicardia*) *petraea* sp. nov. E–F, NMV P142908, paratype, PL3004,  $\times 3.5$ . I–J, NMV P142906, holotype, PL3003,  $\times 3.6$ . K–L, NMV P142907, paratype, PL3003,  $\times 2.6$ . O–V, *Bertinella lapidaria* sp. nov. O–P, NMV P142922, paratype, PL3003,  $\times 1.7$ . Q, U, NMV P142920, paratype, PL3004,  $\times 1.7$ . S, NMV P142920, paratype,  $\times 3.4$ . R, V, NMV P142921, holotype, PL3003,  $\times 1.8$ . T, NMV P142921, holotype,  $\times 3.4$ .

pair. This species is closely related to *Venericardia* (*Rotundicardia*) *latissima* (Tate), Late Eocene of southern Australia, from which it differs by having the triangular right valve central tooth oriented obliquely rather than laterally as in *V. (R.) latissima*, the outline is more rounded with a broader anterior end and it has fewer ribs (21–26 rather than 25–29) than *V. (R.) latissima*.

### *Carditellopsis* Iredale, 1936

*Type species.* *Carditella elegantula* Tate & May, 1901, Recent, Tasmania.

### *Carditellopsis bellissima* sp. nov.

Fig. 6A–C, G–H, M–N

*Description.* Shell small, of average size for genus (2.9 × 3.0–4.6 × 4.7 mm), roundly trigonal, slightly higher than wide, equivalve, with prominent umbos, curved anteriorly; anterior dorsal margin concave, anterior, ventral and posterior margins convex, merging imperceptibly, posterior dorsal margin straight. Lunule heart shaped, smooth, well differentiated. Escutcheon long, narrow, smooth, bounded by sharp ridge. Sculpture of about 15 thick, commarginal, erect lamellae, continuous on dorsal half of valve, broken by radial incisions on ventral posterior half of valve. On some specimens, commarginal sculpture broken up into a series of aligned coarse elongate tubercles over entire surface of valve.

Hinge: left valve, posterior socket long, flanked by slight ridge or swelling on inner side of hinge and edge of valve; posterior cardinal strong, long and narrowing anteriorly; large central triangular socket and short strong, almost peg-like anterior cardinal; anterior lateral marginal, formed from raised surface of edge of valve, a little distant from anterior cardinal. Right valve anterior socket long, deep, flanked by ridge on interior side of hinge and thin edge of valve; central cardinal triangular, strong, slightly bifid; posterior marginal lateral well developed, formed by raised extension of valve margin. Ligament external.

$$\begin{array}{l} \text{RV } \frac{1}{1} - 010 - (1)0(1) \rightarrow \\ \text{LV } (1)0(1) - 101 - 1 \end{array}$$

Anterior muscle scar kidney shaped, longer than wide; posterior scar subtriangular. Pallial line entire. Internal ventral margin with about 16 coarse denticulations.

### *Dimensions*

Holotype P142910	W 4.6	H 4.7	T 2.8
Paratype P142911	2.9	3.0	
Paratype P142968	3.6	3.8	
Paratype P142969	3.5	3.8	
Paratype P142915	3.8	3.9	

*Type material.* Holotype P142910, collected T. A. Darragh, 17 February 1981; Paratype P142911, collected T. A. Darragh, 2 December 1984; Paratype P142968–9, collected T. A. Darragh, 24 November 1992; Paratype P142915, collected T. A. Darragh, 8 March 1971.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (1 specimen), PL3003 (45 specimens), PL3004 (5 specimens).

*Remarks.* There are two articulated pairs present in the sample. Three specimens have countersunk gastropod boreholes. The pair of posterior laterals in the left valve, stated by some authors to be present in this group, is barely recognisable in this species. The hinge is similar to that of *Carditellopsis elegantula* (= *valida* Verco), Recent, southern Australia, but the teeth in the latter are slightly curved to the anterior because the umbo and hinge area are slightly curved. The sculpture of *C. bellissima* sp. nov. is much coarser than that of the *C. elegantula* and the valves are not so tumid. *C. bellissima* sp. nov. is probably ancestral to *C. rugosa* (Tate) from the Late Eocene of southern Australia, but the sculpture is much coarser than that present on the latter.

The ancestral genus seems to be *Vetericardia* of the Late Cretaceous of North America, which has similar sculpture and hinge to *Carditellopsis*. Somewhat similar species in the early Tertiary of Europe were referred to *Choniocardia* by Glibert & Van de Poel (1970).

The group seems to be absent from the early Tertiary of New Zealand and Antarctica.

### Family LAHILLIIDAE

#### *Lahillia* Cossmann, 1899

*Lahilleona* Finlay & Marwick 1937: 31.

*Type species.* *Amathusia angulata* Philippi, 1887, Miocene, Chile.

Zinsmeister (1984) showed that species of *Lahillia* possessed a pallial sinus and synonymised *Lahilleona* with *Lahillia* since the feature alleged to separate them was the absence of a sinus in the latter and its presence in *Lahilleona*.



**Lahillia australica** Singleton, 1943

Fig. 7A-G

*Lahillia australica* Singleton 1943: 273, pl. 12, figs 3-5. —  
Ludbrook 1973: pl. 24, figs 4-5.

**Description.** Shell large ( $67 \times 64$ – $80 \times 70$ ), thick, inequivalve, almost equilateral, moderately inflated, ovate to subtrigonal; anterior and posterior dorsal margins concave; posterior dorsal margin merging into posterior margin; posterior margin slightly convex; ventral and anterior margins convex, continuous, abruptly truncated by anterior dorsal margin. Umbones slightly prosogyral, projecting, subcentral. Posterior ridge on valve ill-defined. Lunule large, lanceolate, sunken, poorly defined. Surface of valve sculptured with irregularly spaced growth striae only.

Hinge plate thick. Left valve with stout peg-like, subcentral cardinal tooth flanked with deep sockets; posterior cardinal thin, poorly defined; nymph large, flattened, produced dorsally beyond hinge plate, separated from posterior dorsal ramp by deep ligamental groove; posterior lateral short, stout, flanked dorsally by long narrow socket; small triangular area at umbo against posterior cardinal forming pseudo resilifer. Right valve with anterior cardinal tooth weak, poorly defined; posterior cardinal prominent, stout peg-like, separated from anterior cardinal by deep triangular socket; nymph broad triangular extended; posterior lateral short stout, flanked dorsally by deep, wide socket.

RV 01 n 101 →  
LV 1 n1010

Pallial line faint with shallow sinus. Internal valve margin smooth.

**Dimensions**

Holotype P128034	L 77	W 73	T 26
Paratype P128036	78	72	28
Paratype P128035	77	71	25
Figured specimen P142917	80	71	25
Figured specimen P142916	75	69	25

**Types.** Holotype P128034 (MUGD 1865), collected G. Baker, January 1942; Paratypes P128035–6 (MUGD 1866–7), collected W. J. Parr, October 1915, presented December 1943. Figured specimens P142916–7, collected T. A. Darragh, 8 May 1979.

**Type locality.** Coastal cliffs  $2\frac{1}{2}$  miles southeast of Princetown, Victoria, second point north-west of Pebble Point (PL 3004, Buckley Point).

**Occurrence and material.** PL3001 (5 specimens), PL3003 (26 specimens), PL3004 (11 specimens), PL3005 (11 specimens).

**Remarks.** This species is more common than

would be supposed from the above numbers, which are low owing to the difficulty of collecting reasonably complete specimens.

Species of the genus are distributed from the Late Cretaceous to Early Miocene in New Zealand (Late Cretaceous–Early Paleocene), New Caledonia (Late Cretaceous), southern South America (Late Cretaceous–Early Miocene) and Antarctica (Late Cretaceous–Late Eocene). Shells are devoid of sculpture and all species look very similar, differing in shape. Compared with *L. neozelanica* (Marshall & Murdoch) the umbones of *L. australica* are more slightly orthogyral and not so produced, the outline is oval rather than subtriangular, the lunule is much less developed and the right anterior lateral is much stronger than in *L. neozelanica* (it is virtually obsolete in the latter). Compared with *L. larsoni* (Sharman & Newton) (Late Cretaceous and Early Paleocene, Antarctica), *L. australica* is more equilateral and not so elongate, the umbones are not so prosogyral and it has a more pointed anterior end. *L. huberi* Zinsmeister (early Paleocene, Antarctica) is very close to *L. australica* but the latter has higher umbones. *L. hui* (Wilckens) (Late Cretaceous, Patagonia) is somewhat similar in shape, but *L. australica* is relatively higher and narrower. Of all the described early Tertiary species, the one that seems closest to *L. australica* is *L. wilckensi* Zinsmeister (Late Eocene, Antarctica) but that species is slightly more elongate than the former.

Freneix (1958) described *Lahillia* (*Lahilleona*) *marwicki* from the Late Cretaceous of New Caledonia based on two internal moulds which did not show the hinge. It is not clear from the figures if this determination is correct, however Freneix (1980) described and illustrated an internal mould showing a shallow pallial sinus and hinge of the left valve which confirms the record of the genus.

**Family TELLINIDAE****Bertinella** Glibert & Van de Poel, 1967

**Type species.** *Tellina donacialis* Lamarck, 1806, Eocene, Paris Basin.

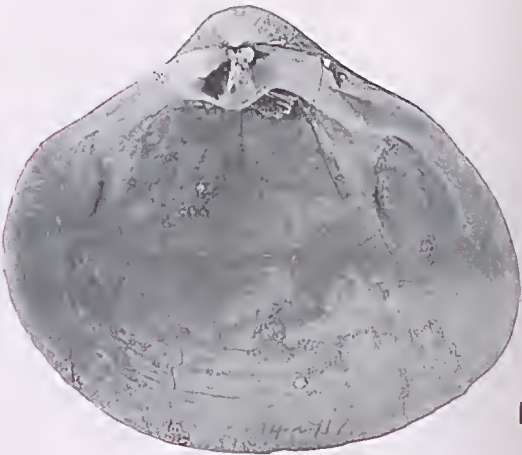
**Bertinella lapidaria** sp. nov.

Fig. 6O–V

**Description.** Shell subtrigonal, equivalve, of average size ( $17 \times 12$ – $22 \times 17$ ); umbones sharp, not projecting; anterior dorsal margin straight; anterior margin strongly rounded, merging imperceptibly with ventral margin; ventral margin gently rounded; posterior dorsal margin straight, merging at sharp angle with ventral margin to form sharp



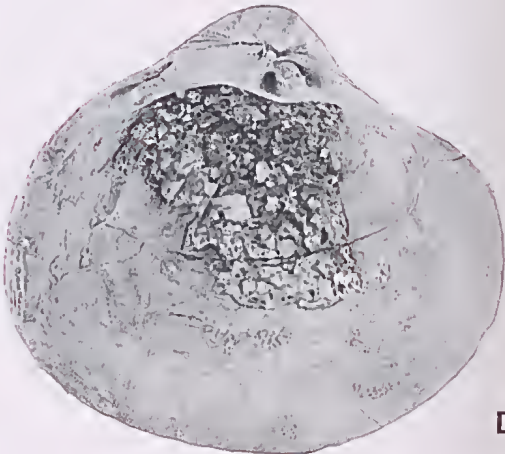
A



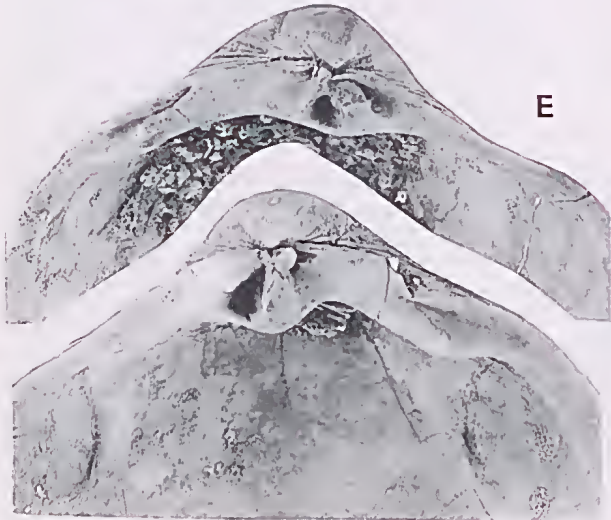
B



C



D



E



F

G



point. Siphonal ridge present running from umbo to posterior point. Right valve with slight flexure on posterior third of flank. Escutcheon very narrow, well defined; lunule narrow and weak.

Sculpture of thin, closely spaced, commarginal, rounded riblets, slightly narrower than interspaces. No trace of radial sculpture.

Hinge: left valve with weak posterior lateral formed by margin of valve; posterior cardinal blade-like, flanked anteriorly by triangular socket; anterior cardinal narrow, triangular, bifid, flanked anteriorly by wide triangular socket; anterior lateral weak formed by valve margin. Right valve with large anterior socket between anterior dorsal margin and short pointed, blade-like anterior lateral; anterior cardinal broad based and becoming blade-like at top; wide, triangular socket posterior to it; strong triangular bifid cardinal posterior to socket; posterior lateral short, pointed, blade-like; long deep socket between it and valve margin.

RV	01	0A01	10	→
LV	1	1	10A0	1

Anterior muscle scar elongate, D shaped, higher than wide; posterior muscle scar subcircular. Pallial line with large rounded pallial sinus extending to centre of valve. Internal valve margins smooth.

#### Dimensions

Holotype P142921	L 21	H 16.5	T 4.5
Paratype P142922	19.5	16	8.5 (pair)
Paratype P142920	24	19	4

*Type material.* Holotype P142921, Paratype P142922 collected T. A. Darragh, 17 February 1981; Paratype P142920, collected T. A. Darragh, 19 November 1970.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (40 specimens), PL3003 (70 specimens), PL3004 (4 specimens), PL3176 (3 specimens), PL3177 (1 specimen).

*Remarks.* Complete well preserved specimens of this species, though thin and fragile, are quite common and the sample contains eight pairs. This suggests the specimens may not have been subject to as much transport as other species. Two specimens have gastropod boreholes.

The correct genus to which this species should be assigned is uncertain because of the large number of taxa available in this family. For the present I have included it, with some diffidence, in *Bertinella*, because of its similarity to other species

assigned to that genus which occur in the Paleocene to Oligocene of Europe and Ukraine. The type species, *Bertinella donaciformis* (Lamarck), is smooth and lacks an escutcheon, but other species included in the genus by Glibert & Van der Poel (1967), such *B. elegans* (Deshayes) and *B. beyrichi* (Deshayes), have an escutcheon and commarginal ribs and are similar to *B. lapidaria* sp. nov. *Tellina dimidiata* v. Koenen, Early Oligocene, Germany seems to be another member of this group and is also very similar to the latter. *Tellina williamsi* Clark, Paleocene to Eocene of the eastern United States of America may be a representative of this group.

*Bertinella* is close to *Serratina*, type species *Tellina serrata* Brocchi, from the late Tertiary and Recent of Europe and may possibly be a synonym. Because *S. serrata* has a very prominent escutcheon and a posterior fold running from umbo to the postero-ventral angle on the right valve and a corresponding groove on the left valve, which are lacking in *B. lapidaria*, I have used *Bertinella*.

#### Family VENERIDAE

##### *Dosinia* (*Dosinobia*) Finlay & Marwick, 1937

*Type species.* *Dosinia* (*Kereia*) *ongleyi* Marwick, 1927, Paleocene, New Zealand.

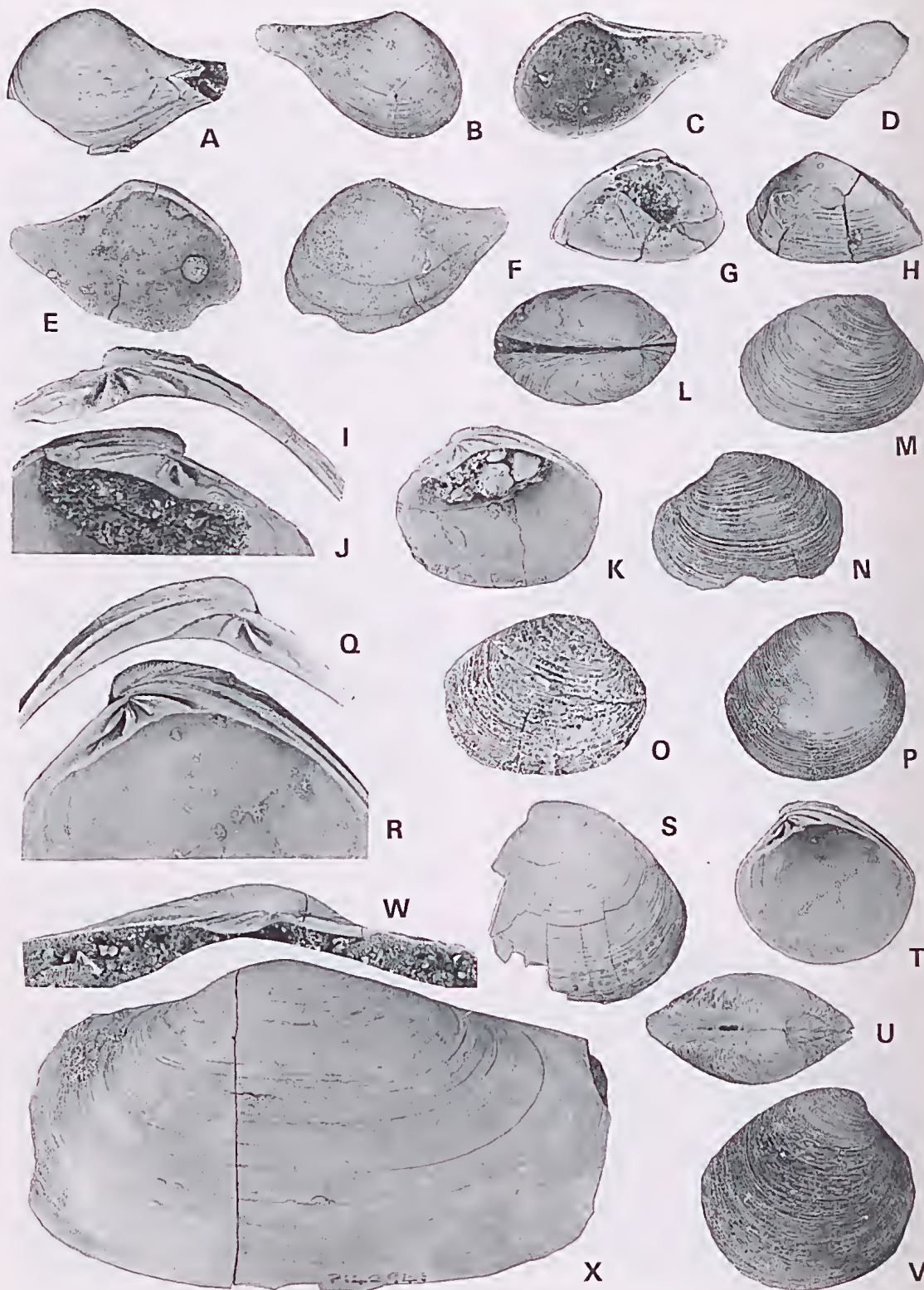
##### *Dosinia* (*Dosinobia*) *saxatilis* sp. nov.

Fig. 8P-V

*Description.* Shell small to medium size for the genus (16×15–18×16), subcircular, slightly inflated, posterior end slightly truncated. Lunule well defined by incised line; escutcheon well defined. Sculpture of thin, close spaced, commarginal lamellae.

Hinge: left valve with long groove between margin of valve and anterior cardinal and lateral; anterior cardinal blade-like, strong, curved, extending anteriorly as a low ridge and produced into a short blade-like anterior lateral; anterior cardinal flanked posteriorly by long curved, narrow triangular socket; central cardinal tooth strong, narrow, triangular, flanked posteriorly by wide triangular socket; posterior cardinal tooth long, thin. Right valve with shallow round socket anteriorly continuous with socket between anterior cardinals, dorsal to it a thin, well developed anterior cardinal tooth flanked posteriorly by deep narrow

Fig. 7. A–G, *Lahillia australica* Singleton. A–B, NMV P142917, PL3003, ×0.8. C, NMV P128034, holotype, second point NW of Pebble Point, ×0.8. D, G, NMV P142916, PL3003, ×0.8. E, NMV P142916, ×1.1. F, NMV P142917, ×1.1.





socket; strong, very narrow, triangular grooved cardinal posterior to socket; deep triangular central socket; posterior cardinal tooth strong, triangular, bifid, elongate, flanked posteriorly by deep narrow socket.

RV 0A0101 0 →  
LV 101010 1

Pallial sinus pointed, wide and deep, extending a third of the distance towards the posterior. Internal margins of valves smooth.

#### Dimensions

Holotype P142926	L 16	H 15	T 4.5
Paratype P142924	19	19	10 pair
Paratype P142927	—	20	7

*Type material.* Holotype P142926 collected 8 March 1971, Paratype P142924 collected T. A. Darragh, 23 November 1992, Paratype P142927 collected T. A. Darragh, 17 February 1981.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (13 specimens), PL3003 (43 specimens), PL3004 (9 specimens), PL3005 (1 specimen), PL3176 (2 specimens), PL3177 (1 specimen).

*Remarks.* Only two specimens are articulated pairs. This is one of the earliest known members of the subfamily Dosiniinae. The hinge of this species is close to that described for *Dosinia* (*Dosinobia*) *ongleyi*, Early Paleocene, New Zealand, but the anterior lateral is a little shorter, the right posterior cardinal is wider and the right central cardinal narrower than in the latter. *Dosinia* (*Dosinobia*) *saxatilis* sp. nov. is much more convex than either *D. (D.) ongleyi* or *D. (D.) perplexa* Marwick, Paleocene, New Zealand, and the sculpture is very similar, though more lamellose in *D. (D.) saxatilis*. The escutcheon is much wider than that in *D. ongleyi*.

Finlay & Marwick (1937) in discussing the distribution of *Dosinia* and its allies pointed out that the earliest Tertiary records of the group are in New Zealand. The occurrence in Australia of this new species of the genus suggests that the group may have had a southern hemisphere origin. There is nothing similar in the Antarctic and there are no known records of *Dosinobia* above the Paleocene

in Australia. Freneix (1958) recorded *Dosinobia* sp. cf. *D. perplexa* from the Late Cretaceous of New Caledonia. The material consisted of internal moulds and the determination seems doubtful.

#### Callistina (Tikia) Marwick, 1926

*Type species.* *Callista thomsoni* Woods, 1917, Late Cretaceous, New Zealand.

#### Callistina (Tikia) ? scopulensis sp. nov.

Fig. 81-O

*Description.* Shell of medium size (14×10–19×15), elongate-ovate, almost subrectangular, tumid; posterior dorsal margin gently convex, abruptly truncated by posterior margin; ventral margin slightly convex; anterior margin strongly convex; anterior dorsal margin short, straight. Umbos strongly prosogyral, not projecting. Lunule not sunken, bounded by groove; escutcheon well developed, elongate-lanceolate. Sculpture of thin erect, somewhat irregularly spaced commarginal lamellae; no radial elements present. Interior of valve margins smooth. Pallial sinus not visible.

Hinge: left valve with posterior cardinal long, blade-like; wide triangular socket anterior to it, socket bounded on anterior by thin curved blade-like central cardinal tooth, separated from anterior cardinal by deep triangular socket; anterior cardinal strong, high, blade-like, curved; anterior lateral short, strong, blade-like. Right valve with shallow anterior socket, anterior and ventral to anterior cardinal; anterior cardinal weak, curved, separated from central cardinal by deep narrow socket; central cardinal stout, subtriangular, separated from posterior cardinal by deep triangular socket; posterior cardinal large, strongly bifid, triangular, directed anteriorly, flanked posteriorly by long narrow socket. Ligament external.

RV 0A0101 0 →  
LV 101010 1

#### Dimensions

Holotype P142929	L 16	H 13	T 9
Paratype P142930	18	15	10

Fig. 8. A–C, E–F, *Cuspidaria* sp. A, NMV P142948, PL3001, ×3.3. B–C, NMV P142951, PL3003, ×3.6. E–F, NMV P142946, PL3004, ×3.6. D, G–H, *Caryocorbula* sp. NMV P142939, pair, PL3003, ×3.6. I–O, *Callistina* (*Tikia*)? *scopulensis* sp. nov. I, NMV P142930, paratype, PL3001, ×3.5. J, NMV P142931, paratype, PL3001, ×3.6. K, O, NMV P142930, paratype, PL3001, ×1.7. L–M, NMV P142929, holotype, PL3004, ×1.75. N, NMV P142931, paratype, PL3001, ×1.7. P–V, *Dosinia* (*Dosinobia*) *saxatilis* sp. nov. P, T, NMV P142926, holotype, PL3003, ×1.75. Q, NMV P142927, paratype, PL3003, ×3.7. R, NMV P142926, holotype, ×3.7. S, NMV P142927, paratype, PL3003, ×1.8. U–V, NMV P142924, paratype, PL3004, ×1.7. W–X, *Panopea* sp. W, NMV P142941, between Rivernook and Pebble Point, ×1.7. X, P142941, ×1.5.

*Type material.* Holotype P142929 collected T. A. Darragh, 19 November 1970, Paratypes P142930-1 collected T. A. Darragh, 28 February 1970.

*Type locality.* PL3004.

*Occurrence and material.* PL3001 (6 specimens), PL3003 (8 specimens), PL3004 (1 specimen).

*Remarks.* Three of the specimens are articulated pairs. This species is provisionally placed in *Calistina* (*Tikia*) because the hinge is somewhat similar and both *Calistina* and *Tikia* have a smooth internal valve margin, and possess an escutcheon and a simple triangular pallial sinus. *Calistina* (*Tikia*)? *scopulensis* sp. nov. is more rectangular than most species in these taxa and has a sculpture of commarginal raised lamellae rather than grooves or ridges. *Calistina* was synonymised with *Aphrodina* in the 'Treatise' but *Aphrodina* has no escutcheon. *Tikia* has been recorded from the Late Cretaceous of New Zealand, New Caledonia and Antarctica. There seems to be nothing quite like this species in the Tertiary of any of these countries.

#### Family CORBULIDAE

##### *Caryocorbula* Gardner, 1926

*Type species.* *Corbula alabamiensis* Lea, 1833, Eocene, United States of America.

##### *Caryocorbula* sp.

##### Fig. 8D, G-H

*Description.* Shell small (7.5 × 5), solid, triangular, slightly inequilateral. Umbo orthogyral, situated slightly anterior to mid-line. Anterior and anterior dorsal margins not separated, convex; ventral margin slightly convex; posterior dorsal and posterior margins merging imperceptibly, slightly convex, abruptly truncated at ventral margin to form sharp point. Posterior area narrow, bounded by sharp ridge running from umbo to posterior point. Sculpture of rounded commarginal costae, about as wide as interspaces, less well developed on posterior area.

Hinge: left valve damaged. Right valve with prominent peglike tooth anterior to resilifer. Pallial line well marked; pallial sinus merely a slight indentation.

##### *Dimensions*

Figured specimen P142939 L 7.5 H 5

*Figured material.* Figured specimen P142939, collected T. A. Darragh, 17 February 1981.

*Occurrence and material.* PL3003 (6 specimens).

*Remarks.* One specimen is a well preserved fragmentary articulated pair and the others are very worn. This species has some resemblance to *Caryocorbula waihaoensis* Finlay & Marwick, Middle Eocene?, New Zealand, but the latter is more quadrate and not so triangular. It is very similar in shape and sculpture to *C. parilis* (Gabb), Middle Eocene, California.

The genus has a cosmopolitan distribution and is known from the Early Eocene of New Zealand, the Palaeocene of California, south-eastern United States of America, India, Belgium, and Ukraine. There are no comparable species in the early Tertiary of the Antarctic and South America.

This species bears a superficial resemblance to *Corbula pyxidata* Tate, Late Eocene, southern Australia, but has not so large a posterior area, is not so inflated and lacks any suggestion of a posterior rostrum. Some specimens of *C. pyxidata* have accessory plates preserved and all specimens are rostrate, features that suggest it belongs in *Caestocorbula*.

#### Family HIATELLIDAE

##### *Panopca* Menard, 1807

*Type species.* *Mya glycymeris* Born, 1778, Recent, Mediterranean.

##### *Panopca* sp.

##### Fig. 8W-X

*Description.* Shell, relatively solid, elongate oval, of medium size for genus (60-75 mm), regularly convex, tapering very slightly posteriorly, only slight gapc. Umbo broad, strongly incurved, orthogyral, situated at about anterior 1/3 third of shell length. Anterior dorsal margin short, straight and subparallel with ventral margin; posterior dorsal margin slightly concave; anterior margin strongly convex, merging imperceptibly into ventral margin; ventral margin very gently convex; posterior margin strongly convex.

Sculpture of low coarse, commarginal folds extending about 5 mm from umbo, fading rapidly ventrally. Major portion of valve sculptured with growth striae only; flank covered with microscopic sculpture of fine radial, nodulose threadlets, eroded off most specimens.

Hinge of left valve with prominent elongate triangular resilifer, with deep incision close to valve edge and single blade-like tooth. Right valve not known.

Pallial sinus extending to beneath umbo.

##### *Dimensions*

Figured specimen P142941 L 60+ H 35



*Figured material.* Figured specimen P142941, J. Dennant Collection.

*Occurrence and material.* PL3001 (1 specimen), PL3003 (3 specimens), PL3005 (4 specimens); between Rivernook and Pebble Point (1 specimen).

*Remarks.* All specimens are fragmentary. Of Australian species the Pebble Point taxon comes closest to *Panopea agnewi* (Tenison Woods), Early Miocene, but the umbo is broader and not so far forward, and the valve surface has coarse folds only near the umbo unlike *P. agnewi* in which the folds extend well down the valve. *P. ralphi* Finlay, Middle Miocene, has the umbo situated even further forward than *P. agnewi*. The Pebble Point taxon is distinguished from species from the later Tertiary of Victoria by its relatively smooth surface, lacking folds, and its small gape.

This species has some resemblance to the smooth forms of *Panopea gurgitis* (var. *neocomiensis*), Cretaceous, Europe, but that species has the umbo situated further towards the anterior. It is very similar to *P. eightsi* Stilwell & Zinsmeister, Late Eocene, La Meseta Formation, Seymour Island and also to *P. elongata* Conrad, Paleocene, Acquia Formation, eastern U.S.A.

#### *Cuspidaria* Nardo, 1840

*Type species.* *Tellina cuspidata* Olivi, 1792, Recent, Mediterranean.

#### Family CUSPIDARIIDAE

##### *Cuspidaria* sp.

Fig. 8A-C, E-F

*Description.* Shell elongate ovate, rostrate, tumid, of average size for genus (10×6.5 mm); umbo opisthogyral, not projecting; anterior dorsal margin long convex; anterior margin short, strongly convex, continuous with dorsal margin; ventral margin convex then concave where it forms posterior rostrum; posterior dorsal margin concave extending to form posterior rostrum. Sculpture of thin, widely spaced, commarginal ribs present either on dorsal third of valve only or over whole of valve, other portion of valve sculptured with prominent growth ridges. Rostrum with three fine widely spaced radial threads, one of which bounds rostrum ventrally. Hinge with small resilifer under umbo, teeth if present in left valve not visible on available material. Right valve with long posterior lateral tooth. Posterior adductor scar subtriangular deeply sunken; anterior scar not visible.

##### *Dimensions*

Figured specimen P142946	L 10	H 6.5
Figured specimen P142948	9.5	7
Figured specimen P142951	8	5.5

*Figured material.* Figured specimens P142946, P142948, P142950 collected T. A. Darragh, 23 November 1992.

*Occurrence and material.* PL3001 (1 specimen), PL3003 (2 specimens), PL3004 (1 specimen).

*Remarks.* Three specimens are left valves and are incomplete or worn. The right valve is complete and relatively unworn. This taxon is very close in morphology to *Cuspidaria subrostrata* Tate, Middle Miocene, Victoria. The sculpture is similar but the outline is subcircular rather than elliptical. In shape it resembles *Cuspidaria raincourtii* Cossman, Eocene, Paris Basin, but that species has close-set, fine commarginal ribs covering the whole valve. The genus occurs rarely in the Paleocene of Europe but is not recorded from the Early Tertiary of New Zealand, Antarctica or from the Paleocene of the United States.

#### Family VERTICORDIIDAE

##### *Verticordia* Sowerby, 1844

*Type species.* *Hippagus ? cardiiformis* Sowerby, 1844, Pliocene, England.

##### *Verticordia* sp.

Fig. 6D

*Description.* Shell small, of average size for genus, subrectangular; umbo prosogyral; sculptured with about 29 well spaced ribs. Valve surface covered with fine granulation.

##### *Dimensions*

Figured specimen P142950	L 6+	H 5.5+
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*Figured material.* Figured specimen P142950, collected T. A. Darragh, 23 November 1992.

*Occurrence and material.* PL3003 (3 fragments), PL3004 (1 specimen).

*Remarks.* All specimens are fragmentary, but one fragment shows well preserved sculpture.

The genus occurs in the Paleocene and Eocene of Europe and the Paleocene of North America. The material is not well enough preserved for detailed comparison, but the available material bears a close resemblance to *Verticordia granulosa* Ravn, Early Paleocene, Denmark and Ukraine.

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